PSYCHICAL PHYSICS

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PSYCHICAL PHYSICS

A SCIENTIFIC ANALYSIS OF DOWSING, RADIESTHESIA AND KINDRED DIVINING PHENOMENA

by

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Dedicated to all who furthered the development of the science of divining phenomena.

But before all to my father, who initiated my interest in dowsing phenomena.

To my mother who always stressed the point not to reject facts which do not seem to fit into the frame of our minds and which appear inexplicable by current theories.

To my wife, without whose continuous assistance and constructive suggestions this book would never have appeared.

CONTENTS

INTRODUCTION

The main object of this work is to give an explanation of such aspects of divining as dowsing, radiesthesia, etc., by an analysis of the influence of external electro-magnetic fields on psychic and physiological phenomena in living organisms.

Divining is made up of a group of phenomena which, until recently, interested only para-psychologists, metaphysicists, spiritists, dowsers and other persons concerned with similar work. Scientists generally dislike being involved in any research which deals with these so-called "supernatural", "para-normal" problems and for the most part reject them — without further critical analysis — as being non-scientific and of interest only to charlatans.

Diviners use either divining rods — to discover water or valuable physical matter, i.e., ore deposits, buried objects, etc. — or pendulums. Those who use the latter are called radiesthesists. The rod or pendulum turns or deviates in the hands of the diviner, not only in the neighbourhood of non-living objects, but also of living organisms, whether plants, animals or human beings.

Only a relatively small number of people appear to possess this capacity for divining. Generally speaking, they are afraid of undergoing a scientific test and they often refuse to allow other people the use of their divining rod, fearing that their supernatural qualities might be impaired should it be touched by a sceptic. If one adds to this unscientific attitude the extremely unattractively written publications of most diviners (and which lack all scientific basis) it is not surprising that the majority of scientists fail to be interested in divining phenomena.

Nonetheless, undeterred by public ridicule, persistent generations of dowsers have upheld their belief for at least 7,000 years, almost as long as civilization itself has existed. This should suggest even to the most critical scientist that there may be some possibility of truth in the stories of diviners. "Our mind has the tendency to reject the things that do not fit into the frame of scientific or philosophical beliefs of our time. Too often scientists willingly believe that facts that cannot be explained by current theories do not exist" (ALEXIS CARREL: *Man the Unknown*). Even amongst the more broad-visioned scientists, however, it is difficult to find one who is willing to make a careful study of divining phenomena. This is not surprising and there are several reasons to explain their attitude:

1. There are obviously a great number of charlatans amongst professional and non-professional diviners; these are unhappily apt to discredit their genuine counterparts.

2. It is very easy to devise certain experiments to test diviners and obtain negative results:

a. The experiments described in chapter III, part I, sub 5. D show that many external factors are able to disturb the ordinary reactions of dowsers, similar to various physical conditions such as temperature, etc., which often disturb the regular registration by a physical instrument. Without the knowledge of these disturbing factors accuracy of measurements are impossible.

b. Many diviners make the mistake of claiming that they are able to indicate certain hidden objects, underground ore deposits, water, etc. They fail to realize that many external influences can create the same physiological reactions, similar to readings with modern geophysical instruments, which could be the same under different external conditions.

c. When testing a diviner it is often the subconscious wish of many research workers to obtain a negative result as mentally they are not completely neutral. An accuracy is therefore required from the diviner which is not demanded from an ordinary physical instrument and if errors are obtained the examiners do not consider that mistakes were perhaps made during these tests. A good example are the experiments made by the Geophysical Institute in Switzerland in 1946 (see Bibl. No. 930).

The task in this publication is three-fold: first to establish whether the different divining phenomena really exist or are due only to suggestion; secondly, when established, to study all the disturbing factors; thirdly to analyse whether the reactions of diviners (after they have proved to be real) can be used as indicators for certain external physical conditions.

The author, a geologist, met many dowsers in his work and always was extremely sceptical about their capacities; the results he had seen were not very convincing. Around 1940, however, more and more important data were collected which indicated that divining phenomena were as real as electricity and other physical phenomena. In 1946 and 1947 scientific tests were arranged in the physical and physiological laboratories of Leiden University (Holland) and in the laboratory of Technical Physics at Delft (Holland).

These experiments with artificial magnetic fields and string-galvanometers indicated:

1. that divining phenomena are not due to charlatanry and suggestion but really exist and that the number of people sensitive to these phenomena is greater than is usually assumed;
2. that a great number of physical and physiological factors might cause errors in the registration of these phenomena by our nerves and muscles; this could explain most of the so-called "failures" of scientific tests on diviners;

3. that these phenomena can be explained by the normal physical and physiological laws; therefore they should not be called para-normal nor do they belong to para-psychology;
4. that many of the so-called para-psychological phenomena might be explained by the same methods of research, bringing parapsychology into the ordinary medical sciences;
5. that a careful analysis of these phenomena might prove to be of great value to future medical science.

The problem of the physical and physiological causes of divining phenomena and of the influence of external electric fields, magnetic fields or a combination of both on living organisms is extremely complicated, and it is impracticable for one research worker to study the whole problem. A complete treatment of the subject would probably require several thousand pages, each chapter written by its own specialist. Also, rapid development of the scientific study of divining phenomena makes it difficult to give a complete survey of the whole problem at present. We have therefore tried to summarize in this publication only the different aspects of the problems of divining, in order to give the scientific reader an idea of the enormous field of research which is required for the solution of these problems. Should this summary stimulate cooperative work in the field of "*psychical physics*" and remove scientifically unjustified prejudices the author will feel sufficiently rewarded for his work.

The book is divided into three main chapters.

In the first chapter an analysis is given of the electro-magnetic fields in and around living organisms. This problem is divided into three parts: the electro-magnetic fields created in the living body (the so-called *organic field*), those in the upper part of the earth crust (*geophysical field*) and those in the atmosphere (*climatological* or *meteorological field*). The interaction of these three fields is reviewed and the author has endeavoured to demonstrate that the existence of divining phenomena can be expected even on theoretical grounds.

In the second chapter further evidence is gathered to support this theoretical possibility and a summary is given of the different influences of electrostatic, electro-magnetic and magnetic fields on living organisms.

In the third chapter the divining phenomena are analysed scientifically and the experiments of the author described in detail. This chapter is divided into five parts: *Rhabdomancy* (water divining, etc.), *radiesthesia* (pendulum phenomena), *magnetizer phenomena*, *sensitivity for direction of animals* (this fourth part is included as the previous chapters may also give a clue to this problem) and finally a short *review of the possible applications of the previous analyses on other para-psychological phenomena* (*psychical physics*).

A summary of basic physical conceptions and units is included in the appendix for those readers who are not sufficiently acquainted with electro-magnetic terminology.

An extensive bibliography has been prepared for those interested in further research work in this line. A number of these articles were studied in the original publications, but at present many are unobtainable and we have had to satisfy ourselves with the summaries of these articles.

CHAPTER I

ELECTRO-MAGNETIC FIELDS IN AND AROUND LIVING ORGANISMS

In order to understand the interaction of electro-magnetic processes in living organisms it is not only essential to know the electro-magnetic fields in the living body (which we shall call the *organic field* as it is created by living organisms mainly composed of organic compounds) but also the external fields around the living body. These external fields belong to two spheres of the earth, the lithosphere or earth crust and the atmosphere. The former creates electro-magnetic fields below the organisms living on the lithosphere. These electro-magnetic fields are mainly included in a sub-science of geology called geophysics and for this reason we have given those fields the name of *geophysical field*. The second sphere, the atmosphere, creates electro-magnetic fields around and above the living organisms on earth. They are of particular interest in climatology and meteorology. For this reason we call this third group of important electro-magnetic fields the *climatological* or *meteorological field*.

PART I: THE ORGANIC FIELD

The organic field is generally only observable with rather sensitive physical instruments. However, in the animal and plant world we know several striking examples of electro-magnetic fields connected with living processes, which can be observed even without instruments. These phenomena are known as bio-electrical or luciferous phenomena.

The weaker fields are different again for man, animals and plants. It is therefore convenient to divide this part of the organic field into four sections: bio-electricity sensu stricto, the electrical field of man, animals, plants.

1. Bio-electricity
(see Bibl. No. 1-6)

Certain animals and plants are often able to develop strong electric fields as a natural protective weapon. These fields are mainly due to certain chemical processes in the cells, during which part of the chemical energy is transformed into electric energy.

Animals and plants which possess this capacity are called *luciferous*. They show certain light phenomena, known as *luminescence*, in particular *phosphorescence* (although the phenomenon has nothing to do with phosphorus). The luciferous organisms exist for the most part in the tropics. Two groups can be distinguished: one which radiates light as a normal function and another which radiates only under certain conditions, usually connected with disease. In this latter group the luminescen

is mainly due to *luciferous bacteria*. In the first group the radiation is bound to certain organs of the body, it is subject to the will-power of the organism and depends on the presence of free oxygen. However, the radiation is not a function of life only, as the light organs of certain insects, when made wet, can radiate a long time after death.

Due to the studies of RADZIZEWSKY (see Bibl. No. 3) a.o., we know that many organic compounds occurring in living organisms, such as fats, lecithin, cholesterin, essential oils, gallic acid, glucose, etc., radiate in alkaline solutions under certain conditions at normal or slightly increased temperature if they are exposed to free oxygen (particularly if they are shaken). This explains why many marine organisms only radiate in a strong surf.

DU BOIS was able to isolate two protein substances, luciferin and luciferase, which, when together, produce light, a process responsible for light phenomena in several insects and molluscs.

A. EXAMPLES OF LUCIFEROUS ANIMALS

A few striking examples are the following: Luciferous trails of certain *millipedes*; luciferous water round the Ostracod crab *pyrocypris; pholas dactylus*, a stone borer, that radiates light when two substances are brought together: a crystalline substance (luciferin) and a ferment (luciferase); red light radiated by the *rib-jelly fish* (*salpen* and *cleodora*); lilac light radiated by certain *corals* (*gorgonides*); purple light radiated by *fulgora pyrorhynchus*; a tunicate, *appendicularia*, that radiates red light which changes into blue and finally into green; different insects, such as *fire-flies* (*luciola, diaphanes, pyrocoelia* and *lamprophorus*) that radiate light which is mostly connected with the sexual functions of those insects (in case of the European *glow-worm* the non-flying female radiates a much stronger light than the flying male).

Many *deep sea fish* possess complicated organs in the head or other places of the body, which radiate light of different wave length. Of approximately 1,000 species of deep sea bone fish, about a ninth possess light organs which attract prey and perhaps also serve for recognizing each other, particularly during the periods of procreation. For example, *thaumatolampas* possesses light organs that radiate blue, red and white light. The starfish *brisinga* does not possess a light organ but secretes a radiating slime that covers the whole body.

Certain fish are able to create such strong electrical potentials that they cause unconsciousness in animals or man who swim in their neighbourhood. Examples are *gymnotus electricus* (the electric eel), which develops electrical potentials of up to 800 V, the *electric ray fish* (Torpedo Occidentalis), *torpedo marmorata, malopterurus*, etc. The process of development of such high electric tensions is not yet known in all its details, but is comparable on the whole to the development of

action currents in muscles (see p. 160). The electric organ of the fish is composed of a great number of lamellae, each acting as a separate electric element. The elements are connected in series and form different columns connected in parallel. GOTCH and BURCH discovered that the electric organ of Malopterurus responds to mechanical or electric excitation of its nerves after removal from the fish. The response commences 0.0035″ at 30°C to 0.009″ at 5°C after excitation. The response is generally multiple and consists of a series of shocks up to 30 in number. However, there is no evidence that the electric organ can be excited by an induced current apart from its nerves, i. e., it does not seem to possess independent excitability.

The following table gives a summary of important physiological data of a few electric fish.

kind of animal	number of lamellae per column	number of columns	position of the plane of the lamellae in relation to longitudinal axis of the fish	max. electric voltage in one element in mV	max. voltage during complete discharge in V
Torpedo marmorata	400[2]	500[2]	in the axis	80[6]	30[6]—50[9]
Malopterurus	—	—	under the skin	48—80[7-6] 400[8]	356[10]
Gymnotus electricus	6000[3]	20—50[4]	perpendicular[4]	140[6]	> 800[5]
Raja	15/cm[1]	420-1182	perpendicular[1]	20[1]	150[11]

[1] acc. to Burdon, Sanderson and Gotch; [2] acc. to Fritsch; [3] acc. to Sachs; [4] acc. to Ballowitz; [5] acc. to Cox; [6] acc. to Rosenberg; [7] acc. to Gotch and Burch; [8] acc. to Sürder; [9] acc. to Auger and Fessard; [10] acc. to Koike and Remmler; [11] acc. to Auger, Fessard, Kraukhin and Krayukhine.

Light phenomena occur not only amongst the more highly developed organisms. A well-known example in the group of Protozoa is *noctiluca miliaris*, which populates the sea during the hot summer days and causes the light phenomena. The latter are due to complicated metabolic processes of these animals.

B. EXAMPLES OF LUCIFEROUS PLANTS

To this group belong the *luciferous bacteria*, which cause a diffuse light in seawater and on a wet beach. They probably cause the luminescence phenomena of freshly caught sea-fish, and also of dead fish, meat, milk, corpses, etc. In the nineteenth century, before the regular use

of antiseptics, military surgeons described many cases of luminous wounds and expressed the opinion that such wounds were more likely to heal as the luciferous bacteria would drive out pathogenic species. Luminescence phenomena of mouldered wood and putrifying leaves are caused by *moulds* and *fungi* and certain *toadstools* (*rumphius*); this explains luciferous phenomena in the evening after rain.

As the transformation of chemical energy into electrical energy is treated on p. 160, the luciferous phenomena are not treated any further in this section (see also p. 71, photo-dynamic action of light).

2. Electric field of man

In order to understand the electric field of man six important physiological units should be reviewed. Although a complete description of each of these units can be found in several handbooks on medicine, particularly on physiology, the discussion in the second and third chapter can be more easily understood by the average natural scientist after a summary is given of the six main electric units of the human (and animal) body: the cells, the nerves (and nerve systems), the brain, the heart, the muscles and the skin.

A. The Cell

The smallest, but most interesting unit of the living organism is the cell. Five important characteristics of the living cell are reviewed: the structure (both of the animal and vegetable cell), the electric properties, cell-radiation, the limit of sensitivity of protoplasm to physico-chemical influences and the main laws of cell development.

2. A. 1. Structure of the cell
(see Bibl. No. 7-29)

The structure and composition of the cell is different in the animal and vegetable cell.

The animal cell is composed of seven important parts: the protoplasm, the cell-nucleus, the centrosome, the vacuoles, the mitochondria, the chromosomes and the genes, the most essential part being the *protoplasm*.

Protoplasm can be defined *physically* as a heterogeneous, colloidal, chemical system, composed of electrically charged, strongly hydrated particles, the *micellae*, being continuously in a labile equilibrium. *Chemically* it could be described as a complex mixture of *proteins* (abt. 75%), *carbohydrates* (abt. 5%), *lipoids* and *fats* (abt. 15%), *inorganic salts* (abt. 5%) and a great quantity of *water* (up to 90% in embryonic cells), the latter being chemically bound particularly to the micellae, i.e., groups of protein or lipoid molecules with dimensions smaller than 200 $\mu\mu$. Next to these main elements (C, H, O, N,) sulphur, phosphorus, iron, iodine compounds also occur and three complex compounds, not yet chemically defined, i. e., *enzymes*, *vitamins* and *hormones*.

As no particles smaller than $200\mu\mu$ can be observed under an ordinary microscope the previously mentioned particles, the micellae, can be studied only with an ultra or electron microscope.

The study of the micellae has revealed that they are composed of anisotropically organized complexes of mainly hydrated protein molecules, the result of the particular capacity of the element carbon of forming long-chained molecule complexes. They can be compared therefore with the organic fluid crystals (see p. 29).

The crystalline properties of the micellae were discovered mainly by C. Nägeli, H. Ambronn and W. J. Schmidt.

Ambronn discovered two kinds of crystalline structures:

1. auto-birefringence: due to the space-lattice structure (see fig. 1) of the micellae;
2. structural birefringence: due to the position of the micellae in relation to one another (if they are parallel in one plane and if there is a difference in refraction index between the micellae and the medium in between, they react as positive uniaxial crystals; if they lie on top of each other negative uniaxial crystals are formed).

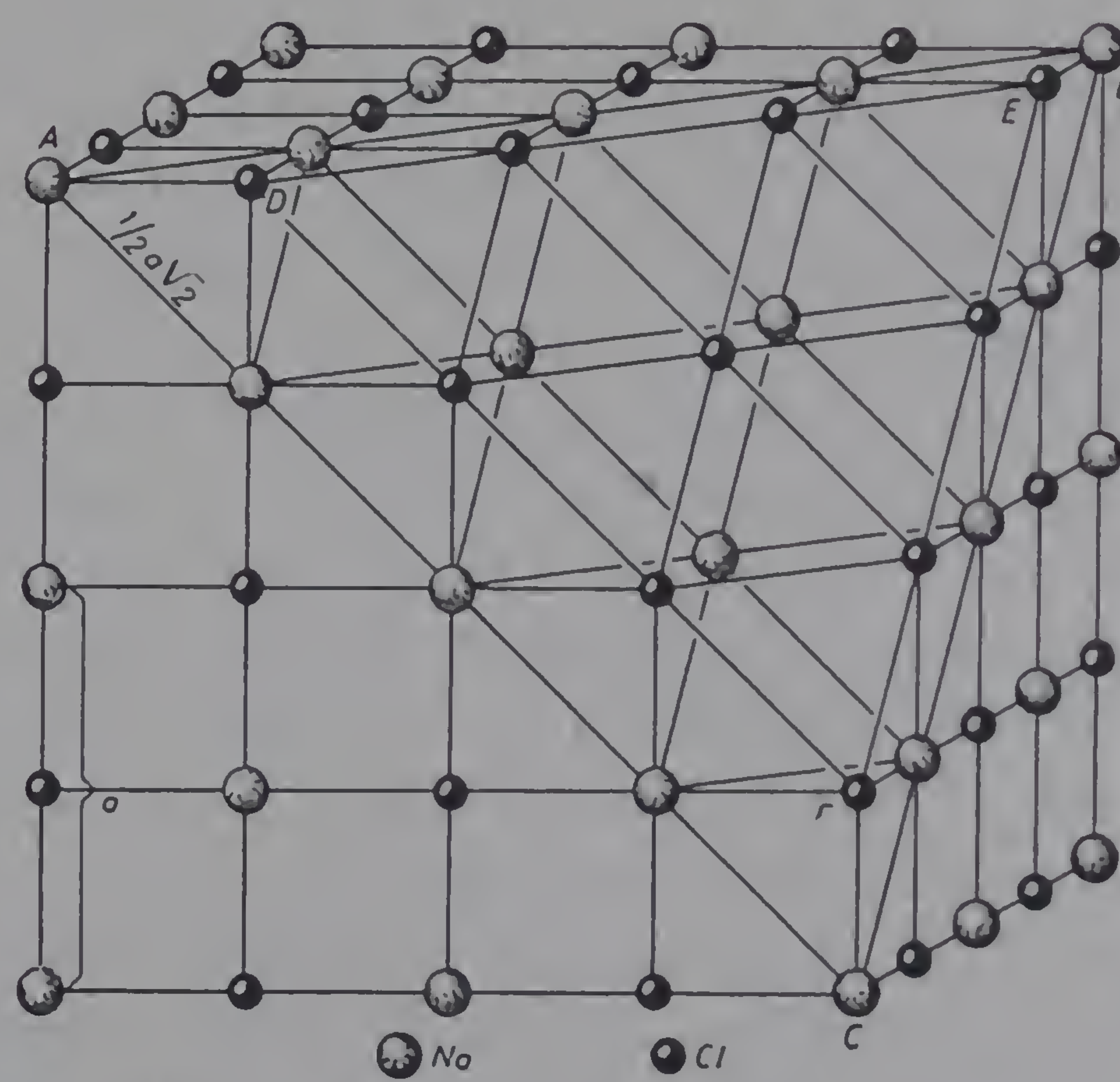


Fig. 1: (Bibl. No. 117, p. 406) Example of space-lattice structure of salt (NaCl), composed of natron and chlorine atoms as material points in the lattices; both cubic and octahedron planes can be seen.

For those readers not acquainted with the optical phenomena in crystals a short summary has been prepared in appendix I on p. 435.

The heterogeneous distribution of those complex crystalline organic compounds in the non-crystallized plasmatic motherlye (mainly composed of water) creates a colloidal system which keeps its lability due to polar electric charges (see electric properties of colloids, p. 55 and electric properties of crystals, p. 16) and the hydration of the micellae.

The space-lattice structures of the micellae, characteristic of all crystalline bodies, both organic and inorganic, explain many properties of the cell, such as cleavage, stretching-strength, etc.

The creation of micelle structures is a process comparable to crystallization processes in the inorganic world. Local variations in temperature and pressure of the plasmatic motherlye, micro-convection currents, variations in viscosity and settling speed of groups of molecules, variations in pH concentration, diffusion and concentration currents, etc., explain the variety in composition and structure of the micellae.

The previous considerations indicate that variations in the surrounding

electro-magnetic fields are bound to create physicochemical and structural changes in the electrically charged colloidal mass of the protoplasm. Section 4 on the limit of sensitivity of protoplasm gives these problems more in detail. A more fluid phase (sol-condition) might change suddenly into a more solid one (jelly-condition), etc. A jellified colloid composed of inorganic molecules might flow out if the colloid is shaken, a phenomenon called *thixotropy*. Protoplasm, if touched mechanically, also flows out suddenly (see movements of pseudopodia of Protozoa).

The different activities of protoplasm require energy. In order to obtain this energy organic compounds (particularly carbohydrates and fats) in the neighbourhood are absorbed and disintegrated by oxidation processes. Oxygen enters slowly by diffusion in the protoplasm; CO_2 disappears in the same manner. This process of oxidation is regulated by *enzymes* (i.e., organic compounds resembling proteins and acting as catalysts), that act as so-called *oxidases* (i.e., oxygen-transferring agents). Depending on the intensity of the binding of the oxygen with those enzymes the intensity of the combustion process varies, a process known as *assimilation*. The specific structure and composition of the micellae and surrounding fluid and of those oxidases determine the activities of the protoplasm and it is therefore understandable that such a great variation in organic life is possible.

The protoplasm needs also salts and proteins besides the carbohydrates and fats. It has a variable permeability for certain ions (salts), depending on the particular colloidal phase of the outer layer of the protoplasm. Foreign proteins are absorbed from the surrounding area and disintegrated into aminoacids; these are built up again with the help of enzymes into protein molecules suitable for the protoplasm.

In the living bodies, next to the organic cell (with a diameter of a few μ; $1\ \mu = 0.001$ mm) other organic bodies often occur which resemble the ordinary cell, though they are generally smaller. They are the *bacteria* (bacterium prodigiosum $= 750$ mμ) and *viruses*. The former are discussed on p. 54 (sensitivity of colloidal substances to electric fields). In connection with the crystalline structures of the micellae it is interesting to review briefly the physical properties of the *virus*, the more so as chapter II includes the influence of external electro-magnetic fields on those different organic bodies. Bawden gave the definition: "A virus is an obligately parasitic pathogen with at least one dimension of less than 200 mμ". Very small quantities are able to reproduce continously and create infectious diseases similar to infections by bacteria. A group of scientists are inclined to believe that they are only *bio-chemical catalysts* that force the living organisms to develop small quantities of complicated proteins which are infectious for that organism.

Stanley studied the virus of the mosaic disease of tobacco plants and was able to separate the virus as protein crystals that are still infectious. This would suggest that the virus is a complex, non-living, nucleo-protein molecule, comparable to the fluid crystals (see p. 29),

with a molecular weight of 10 to 17 million. The chemical composition of the *tobacco mosaic virus* is as follows: Carbon 50%, Hydrogen 7.3%, Nitrogen 16.5%, Sulphur 0.4%, Phosphorus 0.5%, Ash 2.0%, Carbohydrates 2.5%. Different viruses contain widely different amounts of phosphorus and carbohydrates. The specific gravity of the tobacco virus is 1.3-1.37.

BAWDEN, PIRIE, BERNAL and FANKUCHEN (1936) could prove that viruses have a rod-shaped crystalline structure causing anisotropic light phenomena under a polarization microscope. BERNAL and FANKUCHEN (1939) examined the virus solutions with X-rays, and the result indicated that the viruses contain particles orientated parallel to one another. They discovered also that the distances between the particles in liquid crystalline preparations are inversely proportional to the square root of the concentrations.

It has been suggested that the virus crystals act as crystallization catalysts in living tissue, which could be one of the causes of infectious disease.

Irradiation with ultra-violet light or X-rays with wavelength below 260 m μ, and treatment with chemicals such as formaldehyde, heating, oxidizing agents, etc., destroy the infectivity of the viruses without affecting the serological activity. The changes created in the space-lattices of the viruses during this process have not yet been discovered (see p. 68, sensitivity of solutions to electro-magnetic waves).

A few words must be said about the other six main components of the animal cell.

The *cell nucleus* is part of the protoplasm, but is surrounded by a layer of the protoplasm, the so-called *nucleus membrane*. The nucleus is composed of a small light-refracting core, the *nucleolus*, and a fine pattern of glistening grains and fragments, the *chromatin grains*, which are probably composed of optically negative uniaxial crystals of micellae. The remaining part of the nucleus reacts optically isotropic. The nucleus also contains those components of the cell that determine the most specific character of organisms, the *chromosomes* and *genes* (see later).

The *centrosome* is also part of the protoplasm. It is the so-called dynamic centre of the cell, from which the plasm radiates in different directions. These radiation figures are caused by local jellifications of the protoplasm, which are composed of bipolar micelle crystals. They play an important role during the indirect or mitotic cell-division and in the development of special motile processes.

The *vacuoles* are spaces in the protoplasm filled with food reserves, etc.

The *mitochondria* are round or rod-shaped bodies composed of optically positive uniaxial micelle crystals. They resemble the fluid crystals with their winding movements in slightly viscid protoplasm. Their function is unknown, but they probably influence the oxidation processes in the cell and might be the cause of secretion of the gland cells.

The *chromosomes* too are probably complexes of curled fibres, composed

of micelle crystals appearing only during the so-called indirect or mitotic division of the cell nucleus. Each chromosome is a very viscid body, composed of an achromatic axis, closely entwined by a chromatic spiral and made up of smaller units, the *genes*. These particles differ mutually, both in chemical composition and physical structure and it is because of these variations that the possibilities of development of fertilized cells into future living organisms are almost unlimited. The genes, probably with a micelle structure too, appear to act as catalysts in the protoplasm, but at the same time they are auto-catalytic, i.e., by absorption of organic compounds from the surrounding fluid they are able to build up and multiply themselves. The genes not only determine the later characteristics of the species, the varieties of each species and individual differences between the varieties, but also the potential capacities of each cell and their functions in the future living body.

In contrast to the animal cell, the *vegetable cell-space*, the so-called *protoplast*, is surrounded by a *cell-membrane*. The vegetable cell should therefore be divided into two main units: the cell-membrane and the protoplast, the latter being sub-divided into the following six main units: cytoplasm, cell-nucleus, plastides, inclusions, chromosomes and chromomeres, vacuoles and cell-sap.

The *cell-membrane* serves as a protection of the protoplast. It is made up of different parallel layers (lamellae), mainly composed of cellulose. They often change their composition and structure because of external physico-chemical forces (process of lignification, corkification, etc.).

The *cytoplasm* is the most important component of the vegetable cell, comparable to the protoplasm of the animal cell. Whereas in the animal cell the whole space of the cell is filled up with protoplasm, in the vegetable cell only in the embryonic cells, at the extreme end of the root or stalk of plants is the space filled up with cytoplasm. In the older cells, due to stretching phenomena, only part of the cell space is filled. The spaces created by the lack of sufficient cytoplasm are called *vacuoles*. They are filled with a fluid called *cell-sap*, which is mainly composed of water with inorganic salts and different organic compounds such as soluble carbohydrates, jellified carbohydrates, proteins, alkaloids, tannic substances, etc. The sap is often coloured by aromatic pigments, the anthocyanes and anthochlores. The vacuoles also contain oleic fats in emulsion, essential oils, resins, etc. A number of vacuoles often unite to form one larger vacuole and practically the whole cell is finally filled with sap. This is called the *sap-space*, the cytoplasm forming a very thin layer along the wall of the cell membrane. The nucleus also remains in this thin coating of cytoplasm.

The cytoplasm is a colloidal system of very small viscosity, mainly composed of inorganic salts, etc. As in most vegetable cells the cytoplasm takes up a very small space of the cell (because of the cell-sap) and as the cell-sap is particularly rich in carbohydrates, the cells of plants on the whole are poor in proteins compared with the animal cells. The

cytoplasm (like the protoplasm) also appears to be composed of micelle crystals.

In many vegetable cells the plasma is continuously moving. Three kinds of movements are known:

Rotation: the cytoplasm with the nucleus and plastides move in circles along the cell wall (particularly common in water-plants with cells composed of a great sap-space and probably caused by electric currents, see p. 61 and Bibl. No. 249).

Circulation: the cytoplasm moves in different directions (particularly common in land-plants).

Pulsation: in the primitive algae the vacuoles suddenly empty themselves and fill up again slowly, a process repeated rhythmically.

The *cell-nucleus* occurs in the cytoplasm and is composed of cytoplasm of a particular structure. It is separated from the cytoplasm by a *nucleus membrane.* In the most primitive vegetable organisms, such as bacteria and cyanophycea (blue-green algae), the nucleus is absent. In more highly developed plants several nuclei occur in the same cell. Only one nucleus occurs, however, in the most highly developed plants.

The nucleus is composed of several light-refracting cores, the *nucleoli,* and a fine pattern of *chromatin grains.* These grains are made up of nucleo-proteids (i. e., proteins rich in phosphor and insoluble in pepsine), and probably occur as crystalline micellae.

Between the nucleoli and chromatin grains the space of the cell nucleus is filled with *nucleus sap*, a viscid protein solution. In vegetable cells the nucleus is the centre of those components of the cell, which determine the most specific properties of plants, i. e., the chromosomes.

The *plastides* are the third important component of the vegetable cell, composed of small strongly light-refracting bodies. They are missing in the primitive vegetable organisms such as bacteria, cyanophyceae, myxomycetes and toad-stools. In embryonic cells the plastides are very small and almost unobservable. Three kinds of plastides occur in the older cells: the chloroplasts, chromoplasts and leucoplasts.

The *chloroplasts* originate in the parts of the plants exposed to light and are mostly concentrated near the cell wall in the cytoplasm. These, mostly green, chloroplasts, also called *chlorophyll bodies* are most important to the living processes in vegetable cells. They are composed of a colourless ground mass, the *stroma,* in which many small, round, discoidal, probably micro-crystalline green grains occur, the *grana,* which are arranged parallel to the surface of the chloroplasts. They are an extremely complicated mixture of proteins and four colouring pigments: chlorophyll α (blue-green), chlorophyll β (yellow-green), orange red carotene and yellow xanthophyll. *Pyrenoids* are often bound to the chloroplasts. They are round protein bodies often surrounded by radially arranged rhombic crystal needles of amylum.

Whereas in the animal cell the energy required for its activities is drawn from oxidation of carbohydrates and fats, obtained by food

absorption (mainly of plants) and by disintegration of proteins (also obtained from foreign bodies), the grana allow the vegetable cell to build up these chemical compounds out of the carbondioxide in the atmosphere with the help of sunray energy.

Chromoplasts originate either out of the chloroplasts or out of leucoplasts, the third kind of plastide. They are also composed of proteins but only with orange red carotin and yellow xanthophyll as colouring pigments. These pigments occur either as drops in the stroma or as crystals.

Leucoplasts are formed in those parts of the plant not exposed to light. Their bodies are egg-shaped and are stretched by protein crystals in the centre.

The fourth characteristic unit of vegetable cells are the *inclusions*. They originate during the development of the embryonic cell and are often used as food reserves. Three kinds of inclusions are known: fluid inclusions in the cytoplasm (caused by cell sap fat-vacuoles and vacuoles with essential oils and resins); solid inclusions in the cytoplasm (caused by crystals of calcium oxalat, of silica acid and aleuron or protein crystals); inclusions in plastides.

During a certain stage of the metabolic process a mitotic division of the nucleus takes place and the *chromosomes* appear in a manner similar to the animal cell. The number of chromosomes varies between 6 and more than 150, the number being constant for each organic species. They are composed of narrowly coiled fibres, the *chromonema*, lying in a colourless matrix. Each chromonema has a very complex structure. In a weakly coloured matrix many knots occur of different size, the *chromomeres*. Their number and arrangements are constant for each chromosome. The chromomeres are comparable to the grana of the animal cell and are also bearers of the future properties of plants. They too determine the potential capacities of each cell and its future function.

We have discussed rather extensively the structure and composition of both the animal and vegetable cell as only a thorough appreciation of the physico-chemical nature of the cell and its functions enable us to understand the influence of external electro-magnetic fields on living organisms.

2. A. 2. Electric properties of cells

(see Bibl. No. 30-34)

By using basic and acid dyes it has been possible to prove that the cell nucleus is electro-negative in reference to the protoplasm. The nucleolus is less negative again than the nucleus. Thus the cell is a system with a positive nucleolus, a negative nucleus and a more positive protoplasm. The outer solution which surrounds the animal cell differs again electrically from the cell protoplasm. This means that differences

in electric potential exist between nucleolus, nucleus, protoplasm and the external medium. The living cell is therefore the seat of electric forces.

The surface charges of cells can be shown also by their migration in an electric field. In their normal environment they are electro-negative, like most animal colloids (see p. 54). This is correct because proteins are negative on the alkaline side of their isoelectric point, as are most biological solutions on that side, i.e., pH 4.5.

Although the surface layer in smaller cells is allways electro-negative, in larger cells the internal charges might create positive surface charges. These surface potentials are very important to all living processes; this can be demonstrated by the following examples:

1. Bacteria and blood corpuscles are electrically charged. Their stability is determined by this charge (see p. 55). The surface potential of bacteria is probably one of the main factors in their penetration of mammalian membranes, which might be an important measure of their degree of pathogenicity.

2. In 1940 Burr studied (Bibl. No. 30) the potential gradients on the developing frog's egg; 6,000 determinations were made on 50 frogs' eggs before the development of the primary axis of the embryo. The potential differences were measured between the animal pole and four equidistant points on the equator. The following results were obtained:

a. the animal pole is electro-negative in reference to the equator;

b. the main embryonic axis was always situated in a plane containing the max. voltage gradient in reference to the animal pole; the place of the future head of the frog could be predicted on the basis of this gradient;

c. if the frog's egg dies off the potential gradients disappear;

d. the potentials on the equator are different in value.

3. In 1943 Burr and Sinnot studied the relation between the shape of fruits and standing potentials (see Bibl. No. 31), Burr assumed that the organic form of living bodies is mainly determined by their biological field (see p. 198). A study of the fruits of three races of differently shaped Cucurbita pepo with a special apparatus developed by Burr a.o. (see p. 197) gave the following results:

a. the current drawn from the measured system varies from 10^{-9} to 10^{-12} Amperes. The potential differences varied considerably but amounted up to 50 mV. The potential gradient (i. e., the change in potential per mm) varied from 0.2 to 5.0 per mm.

b. The three races have the following forms: elongate, round and flat. The geometric means of ratios between length and width for actual

dimensions, potential differences and potential gradients were as follows:

	elongate	round	flat
length/width	4.080	1.150	0.519
P.D. (length)/P.D. (width) . .	5.570	1.773	0.969
P.G. (length)/P.G. (width) . .	1.370	1.537	1.867

c. The size of potential difference bears little relation to absolute size of the dimensions of the fruit, but the ratio of potential differences is closely related to the ratio of the dimensions.

d. As fruits grow larger the potential gradients tend in all three races to decrease, but the ratios between the gradients in the two dimensions tend to increase in the elongate race, to decrease in the flat race and remain unchanged in the round race.

These few examples sufficiently indicate the importance of electric phenomena in the basic processes of living organisms.

The primary causes of the electric charges on the living cell are difficult to establish for each case separately, but a summary can be given of the different basic physico-chemical processes responsible for the electric properties of the cells:

1. *Electric properties of non-conducting crystalline substances:*

We have seen that most of the important components of the cell are crystalline bodies, comparable to the fluid crystals. Due to the space-lattice structure of crystals the crystal-insulators are characterized by three groups of electric phenomena: *pyro-electricity* (which occurs if a crystal is heated), *piezo-electricity* (the phenomenon that crystals produce electric charges when they are subject to any kind of mechanical pressure) and *di-electricity* (electricity induced in crystals by neighbouring electric fields). In all three cases the amount and distribution of electric charges is determined by the composition and structure of the space-lattices and by their crystallographic properties (distribution of axes of symmetry, planes of symmetry, etc.); these are determined again by the space-lattice structure (see appendix I, p. 435).

2. *Electric properties of colloidal substances:*

As all colloidal suspensions are characterized by electric charges of the particles (see p. 54) the micellae and other particles in the cell also possess electric charges.

3. *Diffusion potentials:*

If an electrolyte is dissolved in a solvent in two different concentrations and the two concentration areas placed in close contact separated by a plane, the following process occurs: as in most electrolytes cation and anion move with different speed, diffusion occurs at the boundary of

both solutions. Electric tensions—the *diffusion potentials*—are created at the boundary. Two kinds of diffusion potentials develop:

a. *Concentration potentials*, caused by different concentrations of the same electrolyte;

b. *Chemical-diffusion potentials*, due to different electrolytes with the same concentration in close contact, but separated by a plane.

These diffusion potentials are generally very small and for the most part less than 10 mV.

As a result of cellular metabolism, different substances diffuse into and from a cell. This creates an intricate system of diffusion flows of different metabolites. The medium through which the metabolites flow offers resistance to the flows. In turn the flowing substances exert *drag forces* on the medium; this might produce elongation of the cells and influence the division processes. The diffusion drag forces are counteracted by the surface tension of the cell.

4. *Membrane potentials:*

Another cause of biopotentials in cells is created if the diffusion of ions near the boundary of two electrolyte concentrations is hampered by the presence of a wall with pores (a so-called *pore-membrane*) or by a so-called *phase-boundary*.

a. *Pore membrane potentials:* The influence of organic membranes with pores of $0.6 - 4 \cdot 10^{-6}$ cm was studied by OSTWALD and MICHAELIS. The pores either allow only certain ions to pass, or they decrease the diffusion speed of certain ions. As a result electric potential differences are created which can considerably exceed the diffusion potentials. Values of more than 100 mV are common. The potentials are greatly dependent on the permeability of the membrane which is a function of the electric charge of the membrane (e. g., a negatively charged membrane repulses anions and makes the membrane completely impermeable) and the size of the pores. X-ray diagrams have shown that many of the organic membranes are semi-crystalline in structure and that the pores are formed by the intermolecular spaces. The organic membranes are composed of proteins, lipoids, etc., which change their surface charge easily in the presence of different solutions; the pH of these solutions is of particular importance. Changes in temperature also influence the membrane potential, causing an increase with rising temperature.

b. *Phase-boundary potentials:* BEUTNER assumes that between two electrolytes a layer might occur in which both electrolytes are dissolved in a certain ratio. Particularly substances insoluble in water can act as such phase boundaries. They are called by BEUTNER *oil membranes*. His theory is based on the theoretical considerations of NERNST and HABER. A phase boundary potential is created near the oil-membranes similar to the potential difference on the boundary between metals and electrolytes (created by the tendency of metals to assume the ionic state by giving up electrons and due to ions in the solution having a tendency

to take up electrons). Whereas the pore membrane-potential is a function of the water channels in the membrane which allows the ions to pass, in the oil membrane the potentials and the mobility of ions are a function of the solubility of the ions in the phase-boundary zone. TEORELL, MEYER, and SIEVERS combined both membrane-theories into one new membrane-theory around 1936. It is not within the scope of this publication to discuss the theory in detail. The few facts mentioned on membrane-potentials indicate sufficiently that modern research on the structure and function of membranes is most essential for the understanding of the living processes.

A special kind of membrane, particularly studied in England, is the *mono-molecular layer*. It is known that a teaspoonful of oil is able to cover a pond half an acre in area. The thickness of such a layer is abt. $2.5 \cdot 10^{-7}$ cm and is created by a mono-molecular layer of this complex organic compound. Matter in the two-dimensional state follows in many respects the laws governing properties of matter in the three-dimensional state. There are, however, many differences.

The electric surface potential of these mono-molecular layers, measured with a so-called air-electrode (i. e., an insulated electrode dipped into the trough and the potential measured with an electro-metric or potentiometric setup), amounts to as high as 900 mV for some sterol-films. The greatest number of studies on mono-molecular layers have been carried out on proteins. They are of greatest importance for a clear understanding of living processes. Aquatic species of plants or animals, for example, are covered with waxy or lipoid films designed to check evaporation. They often have a low permeability for water (films covering apples and other fruit). Internal surfaces of the body such as lining of the mouth, nasal sinuses, gastrointestinal tract, the entire respiratory tract, etc., are covered with films of varying composition, viscosity and permeability designed to control adsorption of food, prevent intrusion of micro-organisms or check excessive evaporation of the cell fluid, etc. The most important mono-molecular layers are external surfaces of the cell; surfaces separating nuclei, vacuoles etc., from the cell-plasma; films situated at the synapses of nerve ganglia (see p. 128), which determine the speed of transmission of nervous impulses, etc. (see also p. 88, sensitivity to homoeopathic concentrations and p. 67 and 72, sensitivity to irradiation).

5. *Alteration potentials of* HERMANN, LUND, MARSH, *and* MEYER:

These scientists assume that oxidizing and reducing processes during the metabolic process in the cell are able to create potential differences. BEUTNER and LOZNER could prove this experimentally for an artificial oxido-reductional system. The E.M.F. amounted to 20 mV, the oxidized substance being electrically positive.

6. DONNAN-*equilibrium potentials:*

They are created by accumulation of certain ions in cells, after a long process of diffusion through membranes, until an equilibrium is reached; this has been studied in detail by DONNAN. If for example, due to its colloidal state, an organic salt of potassium is prevented from diffusing through a membrane which separates also a permeable potassium salt, e.g., KCl, an accumulation of potassium ions might occur, and create a concentration potential of a few millivolt.

7. *Demarcation or injury-potential:*

If an organic cell or group of cells is injured, an electric potential or current can be measured, the damaged part being generally negative in reference to the undamaged part. This is caused by the local disappearance of the membrane and as a result only diffusion potentials occur which are less than the ordinary membrane-potentials. The demarcation-potentials are generally abt. 20-30 mV.

8. *Thermo-potentials of* BERNSTEIN:

Local increase in temperature of a non-damaged cell or groups of cells can make the heated place electrically positive with respect to the surrounding areas. We have mentioned the increase of membrane-potentials if the membranes are heated. A positively charged membrane impermeable for anions will become more impervious and more positively charged after local heating. As soon as local damage of the cell occurs however, as a result of the heating, the positive charge changes to negative. Changes in temperature also create pyro-electric phenomena in the crystalline components of the cell (see p. 16).

9. *Compression potentials:*

Membranes possess a special molecular structure. It is therefore logical to assume that compression of living bodies influences the membrane structure and changes the electric potentials. Compression also causes piezo-electricity phenomena in the crystalline substances of the cell.

2. A. 3. Cell-radiation

(see Bibl. No. 35-94)

In 1858 FREIHERR VON REICHENBACH reported that certain sensitive people are able to observe light phenomena in dark rooms in the neighbourhood of plants; he explained this as being the result of increased cell-division.

In 1923 ALEXANDER GURWITSCH, a famous Russian cytologist, published the result of his experiments with the roots of an onion species, *Allium cepa* (see Bibl. No. 53-62). GURWITSCH brought the roots (still joined to the bulb) of two alliums close together (distance 1.5-2 mm). After a period of 3 to 4 hours the spot on one of the roots (the detector),

to which the other root (the inductor) had been pointing, showed an increased cell-division. It was known that the end of plant roots show increased cell-division phenomena and it was logical to assume that this increase was due either to chemical or physical energy released during the cell-division of the other root.

About 1927 REITER and GABOR (Bibl. No. 81) could prove that a fresh root cut from the bulbs could be used as a detector.

Other experiments by GURWITSCH with yeast cultures gave similar results. One of the yeast cultures was cultivated on beer agar and acted as inductor, whereas another yeast culture, cultivated on pepton-dextrol agar was used as detector.

After a great number of experiments by GURWITSCH, CREMONESE (Bibl. No. 42), DESSAUER (Bibl. No. 43) a.o. it was assumed that during cell-division the cells radiate an electro-magnetic wave; this in its turn causes new cell-divisions in other organic cell groups (see also Bibl. No. 71). The main properties of this radiation — called *mitogenetic radiation* (after mitosis=cell-division) — are as follows:

1. they appear to follow the same laws of reflection, refraction, diffraction, interference and polarization as normal light waves;
2. there are apparently two kinds of mitogenetic radiation: a radiation that can be compared with ultra-violet radiation with wavelength of abt. 0.2 μ (*Gurwitsch radiation*) and an infra-red radiation of unknown wavelength (*Cremonese radiation*). The actual existence of this second radiation is still uncertain;
3. there seems to be a difference in wavelength between GURWITSCH radiations from animal and vegetable cells;
4. the influence of GURWITSCH rays on cell-division varies with the polarization condition of those rays (see Appendix I p. 435).

The experiments of GURWITSCH were repeated with different living tissues by a great number of scientists. Two kinds of experiments are of particular interest: those of SIEBERT with muscles and of WASSILIEW, FRANK, and GOLDENBERG with nerves.

SIEBERT (see Bibl. No. 84 and 85) used as an inductor a mash of electrically stimulated frog muscles placed in a glass tube, the open end at a distance of 3-5 mm from a yeast culture (or an onion root) which acted as a detector. The following results were obtained:

1. a non-stimulated muscle was unable to increase the cell-division of a yeast culture. After stimulation the muscle-mash caused a mitosis that increased from 22-26% (control) to 30-40% (with muscle radiation) over a period of three hours at 25°C;
2. the action of the muscle can be reflected with a mirror. An increased cell-division of abt. 10% was observed exactly at the place where the reflected radiation should reach the yeast culture, which acts as a detector.

SIEBERT made experiments with other tissues. Fragments of the spleen, liver and skin were unable to increase the mitosis. Bonemarrow, tissue of a cancer tumour, increased the cell-division considerably. The lack of influence of cancer tumour and stimulated nerves on the STEMPELL effect (see p. 52) supports SIEBERT's assumption that the phenomenon is not created by volatile components.

WASSILIEW, FRANK, and GOLDENBERG (see Bibl. No. 93) studied the influence of nerves on mitosis in the bio-chemical laboratory of the Institute for brain research in Leningrad. Previous experiments by REITER and GABOR in 1928 with nervus ischiad from frogs failed to show any influence on mitosis. WASSILIEW, however, used the nervus olfactorius (see p. 101) of a pike as an inductor and yeast culture as a detector. The following results were obtained:

1. a non-active nerve increases cell-division;
2. electric stimulation of the nerve did not increase the radiation-activity of the nerve, and often even reduced its activity;
3. a quartz plate between nerve and detector did not decrease the activity;
4. no activity was left after killing the nerve by heating.

The controversy over the results of REITER and GABOR was explained as follows:

1. the nervus ischiad is surrounded by a thick layer of myelin (see p. 128), which might absorb the GURWITSCH radiation. It is known that a thin layer of fatty substances absorbs ultra-violet rays;
2. the metabolic processes in the marrow-containing nerves, such as N. Ischiad., are considerably weaker than in nerves without myelin, such as N. olfactorius. According to MEYERHOF and SCHULZ the difference can be 1 : 10. As metabolic processes appear to be very important in the development of the GURWITSCH effect (see later) it is logical that myelinated nerves should be inactive.

We have deliberately described these different observations as a great number of scientists who attempted the experiments of GURWITSCH were unable to obtain positive results. Others claim that the positive results of GURWITSCH a.o., compared with the negative results, are not above the values to be expected with the theory of probabilities. Of particular interest are the studies of HOLLAENDER and CLAUS (Bibl. No. 65), who claim that positive results are only due to the fact that these research workers were not fully aware of the susceptibilities of their instruments to disturbing influences such as changing humidity, temperature, electric disturbances, etc. The only confirmation of a possible wave character of the GURWITSCH effect, if it existed at all, was found by the same authors during some of their experiments with artificial ultra-violet light, the latter creating an activating effect on mitosis.

Amongst the manifold contradicting results of the different experiments on GURWITSCH radiation one group of experiments should be mentioned;

these were initiated by STEMPELL in 1929 (Bibl. No. 89). He used the rhythmic precipitations of LIESEGANG as detectors for organic radiations. As these experiments are of great importance for the understanding of divining phenomena, they are dealt with extensively on p. 49 (sensitivity of colloidal substances to volatile matter). STEMPELL observed a disturbance in the LIESEGANG figures if a mash of onion roots or other living cells were placed above the gelatine, and even when placed above cellophane or quartz plates (in this case the influence was very weak) attached in an air-tight manner to a closed box with the gelatine. In other words the influence of volatile components seems to be excluded (see however p. 39). STEMPELL's experiments were repeated in 1930 by VAN ITERSON and HOMAN VAN DER HEIDE (see Bibl. No. 67) and by SIEBERT (Bibl. No. 86). They confirmed the STEMPELL effect but insisted that the phenomenon was not due to radiation but to volatile matter emanating from the organic tissues. A great number of experiments were made again in 1931 by STEMPELL and independently by ROMBERG (see Bibl. No. 92), who refuted SIEBERT's and ITERSON's conclusions. They agreed that the disturbances could be caused by volatile matter, but even if precautions were taken in the experiments to eliminate this influence, a radiating effect could still be observed. They discovered also the following interesting effect: increased intensity of artificial radiation furthers the development of secondary rings of LIESEGANG. Intensive emanation of volatile components (if artificially created) decreases this process. In other words, even if a GURWITSCH radiation does exist we can often expect a negative result if both factors counteract each other; this could explain the many contradictory results of research workers who study the problems of GURWITSCH radiation. The extreme subtlety of these phenomena, which also characterizes all the divining phenomena discussed in chapter III, makes it extremely difficult to establish beyond any reasonable doubt that they really exist. But even if the GURWITSCH or STEMPELL effect is not a radiation effect, the phenomenon is just as important and deserves intensive research on the influence of traces of volatile matter on colloidal substances.

In GURWITSCH's original experiments the tip of the detector root after some hours was killed, stained, sectioned and subjected to microscopic examination. This method was improved later by using photography and the photographic cell for detecting ultraviolet rays.

The *photographic method* combines sensitivity to low intensities of light and the ability to summate stimuli over a period of time. Several workers obtained positive results during their experiments, but many negative results were also reported. The positive results might be produced also by vapours (see exp. of RUSSELL, p. 33-48), although GURWITSCH claimed that he prevented this influence by placing quartz and glass-plates between inductor and detector. In the case of quartz plates increase in mitosis still took place, but not if glass were used. This observation

seems to confirm the oscillatory character of the GURWITSCH effect. Since it passed through quartz and was absorbed by glass and thin layers of gelatine, GURWITSCH assumed that the mitogenetic radiation lay in the ultra-violet region around 2,000 Å (1 Å $= 10^{-8}$ cm). GURWITSCH and FRANK (Bibl. No. 46) explained the negative results with the low intensity of the radiation. They assumed that the radiation sufficient to produce an effect on onion roots was 1/200th of that necessary to blacken a plate (i.e., $2 \cdot 10^8$ light quanta per square centimetre).

Several types of photo-electric cells have been used as detectors, in particular a combination of the photo-electric cell with the principle of the GEIGER-MüLLER counter. RAJEWSKY (Bibl. No. 79 and 80), FRANK and RADIONOW (Bibl. No. 48), AUDUBERT, BARTH, SIEBERT and SEFFERT (Bibl. No. 87) claimed positive results. However other investigators, such as LORENZ (Bibl. No. 73), GRAY, OUELLET, KREUCHEN, BATEMAN (Bibl. No. 38), SCHREIBER, FRIEDRICH and GLASSER (Bibl. No. 50 and 51) obtained negative results. GLASSER had some positive results too, but these were not reproducible.

Attempts were made to reproduce mitogenetic effects with ultraviolet light from artificial sources. FRANK and GURWITSCH (Bibl. No. 46) obtained positive results in onion roots with radiation of wavelengths between 1,930 and 2,370 Å. REITER and GABOR (Bibl. No. 81) found positive results between 3,340 and 3,400 Å, but none below 2,800 Å. CHARITON, FRANK and KANNEGIESSER (Bibl. No. 41) found inductive effects between 2,060 and 2,650 Å, but none around 3,400 Å. However, other investigators failed to confirm these positive results (SCHREIBER, KREUCHEN, BATEMAN and GLASSER). HOLLAENDER and CLAUS (Bibl. No. 65), although their general studies on GURWITSCH radiation were negative, reached some positive results relative to the activating effect of ultra-violet light. Parthenogenetic development of Arbacia eggs was produced with ultra-violet rays.

According to GURWITSCH and his adherents *the following living matter can be used as an inductor* under certain metabolic active conditions: onion roots, yeast, bacteria, hydra, eggs of lower animals, plant seedlings, potatoes, beets, blood of man, frogs, rats, cancerous tissue, muscles, nerves, the brain of young axolotls, a mash of Drosopila larvae, a mash of tadpoles, etc. *The observation that these living bodies do not radiate all times and under all conditions is important;* e.g., yeast cultures should first run 12 to 15 hours at 25-28°C, according to GURWITSCH, before a successful radiation is obtained. 20 hours is too long again, etc.

The number of detectors is considerably smaller. *Good detectors* have been yeast, epithelium of cornea and bacteria.

These different observations indicate that even if we can accept the GURWITSCH radiation as a reality, it is only logical to assume that many investigators would obtain negative results. They often attempt to be more critical and careful than those who claim positive results, but by neglecting

the varying periods of radiating activity, they are in fact less scientific in attitude than the others. This again is a good example of the tragedy of scientific research on these extremely subtle living processes. During an as yet little-known process with different factors of which some increase but others decrease a certain effect, it is extremely dangerous to apply the theory of probabilities; there often is no good reason to assume that during the different experiments the ratios between those different factors remain constant. Let us assume that a certain living object for only one week a year is able to demonstrate a certain phenomenon which is due to the particular state of development required. If experiments were made every day (without knowing this fact) on only 7 days in 365 would there be a positive result i.e., abt. 2%. If this phenomenon were to occur every year always in the same week we would be inclined to accept this phenomenon as a reality after several years of experimental work. However, if this period changes irregularly because of different external factors, the chances are great that the phenomenon would be denied on the basis of the theory of probabilities.

Many experimental studies were made of the problem of the actual cause of the GURWITSCH effect. The source of emanation could be due to a chemical process essentially peculiar to life or to some radioactive metal in the protoplasm. This second probability seems not to be the case.

Different experiments suggest the importance of "oxidative processes":

1. SIEBERT (Bibl. No. 85) assumed that the activity of the stimulated muscle (see p. 20) was due to lactic acids (see causes of muscular contraction, p. 158). He added some lactic acid to a non-stimulated muscle, but the GURWITSCH effect was not observable. Other important chemical compounds in the muscular processes, phosphoric acid, choline, etc., were added, but without positive results. However, if the muscle with lactic acid was placed in a current of oxygen positive results were immediately obtained. The oxygen current alone, in contact with a non-stimulated muscle without previous treatment of lactic acid, was inactive. This strongly suggests that the oxidative process in a stimulated muscle is responsible for the GURWITSCH effect.

Addition of slightly oxidizing copper salts with lactic acid in a muscle also gave positive results.

2. According to SIEBERT, oxalic acid (COOH-COOH), which occurs in rhubarb and other plants (see p. 14), when placed in an oxygen current above carbon, creates a GURWITSCH effect similar to that of a stimulated muscle.

3. Cyanic acids in concentrations of 10^{-4}-10^{-5} N. greatly hamper oxidizing processes. Traces of these compounds added to the oxalic acid in exp. 2 made this salt inactive. An electrically stimulated muscle was inactive after treatment with traces of cyanic compounds.

4. According to MAGROU (Bibl. No. 74) and REISS, a GURWITSCH

effect is obtained if glucose is treated with potassium permanganate.

5. Frank and Salkind (Bibl. No. 45) discovered that fertilized sea-urchin eggs radiate most actively in the period of greatest oxygen consumption by the eggs.

We pointed out on p. 6, that Dubois was able to isolate two substances, luciferin and luciferase, which, when together, produce light. Gurwitsch could extract from the onion two fractions which he called in analogy of Dubois, *mitotin* and *mitotase*. *Mitotin* emanates only in the presence of mitotase, probable changing into oxymitotin. This was confirmed in 1930 by Loos (Bibl. No. 72).

A second chemical process which is apparently responsible for the Gurwitsch *effect is "glycolysis"*, i.e., the splitting of glucose into lactic acid, a process common in muscles and other tissues (see p. 158). The following experiments by Potozky and Zoglina (Bibl. No. 78) support this assumption:

1. blood prevented from clotting loses its power of radiation after standing for half an hour, but if glucose is added, the blood will radiate for some 10 min. and then stop, unless more glucose is added;
2. a carcinoma removed intact from the body and put into Ringer's solution, does not radiate, but if glucose is added intense radiation is observed.

A third type of chemical process which, according to Gurwitsch, *is responsible for the* Gurwitsch *effect is called "proteolysis"*, i.e., the breaking down of proteins into their soluble decomposition products (such as peptones), as in the case of the digestion of albumin by stomach juices. This assumption is supported by the following experiments:

1. Karpass and Lanschina (Bibl. No. 68) obtained radiation from the digestion of albumin;
2. Billig, Kannegiesser, and Solowjew (Bibl. No. 39) determined the emanation spectrum of the digestion of albumin by pepsin.

The many contradictions mentioned in the previous pages, however, support Glasser's conclusion that "the important task of the immediate future does not lie in finding applications in related fields (such as Gurwitsch a. o. have done) but it is necessary to establish first beyond any reasonable doubt that the mitogenetic radiation really exists, only then further application in medicine may progress unhampered".

Siebert pointed out that increased mitosis can be observed in certain stages of development amongst anaerobe living organisms. Chemical compounds preventing oxidation cannot prevent increased mitosis of those organisms. This indicates that even if mitogenetic radiation is a reality, oxidative radiation and mitosis do not seem to be necessarily always linked together.

L. Stone could demonstrate in a film the bursts of cell-division in the developing salamander egg. Forces initiating and controlling these

bursts of mitotic activity are probably related to the above-mentioned cause of the GURWITSCH effect.

COOPER reported that mitosis in regenerating layers of skin rises and falls in a diurnal rhythm. Peaks of mitosis occur at night and drop during the day (man). Nocturnal animals such as mice apparently have a minimum during the night and a maximum during the day.

In 1944 BLUMENFELD (Bibl. No. 40) found a possible correlation of the mitotic rates by studying the renal cortex and submaxillary glands, which show a distinct diurnal rhythm.

This review of the GURWITSCH effect has been more extensive than other sections of this chapter on the organic field of man as the historic development of this still-unsolved problem is most instructive for the understanding of the problems and difficulties of the science of divining phenomena.

2. A. 4. Limit of sensitivity of protoplasm to physico-chemical influences

In order to appreciate fully the influence of external electric, magnetic or electro-magnetic fields on living organisms, it is necessary to review some of the basic physico-chemical and physiological experiments which indicate the extraordinary sensitivity of the living cell, and particularly, its protoplasm to physico-chemical influences. The sensitivity of the living cell equals and often exceeds the sensitivity of the most modern physical instruments. This is not surprising when we consider the amazingly complex structure of the living cell (described in section 1).

The sensitivity of the living cell is the result of two factors: the sensitivity of its components separately, which are also known in the non-living world, and the sensitivity of the total structure of the combinations of these components. In order to facilitate the reading of the following pages the different phenomena are tabulated:

I. Sensitivity of the separate main components of the cell to physico-chemical influences (see p. 29-96).

A. Sensitivity of organic crystals (see p. 29-32).

1. Fluid crystals: exp. of LEHMANN, VORLAENDER, a.o.; FARADAY and KERR effect (see p. 29-30).
2. Crystallizing solutions: exp. of OSWALD, WEYBERG, LEHMANN, WULFF and MIERS, RAUBER, GOLDSCHMIDT a.o.; PFEIFFER; poly- and isomorphism (see p. 31-32).

B. Sensitivity of colloidal substances (see p. 32-60):

1. To volatile matter (see p. 32-53):
   a. photographic exp. of COLSON and RUSSELL (see p. 33-48).
   b. exp. with "rhythmic precipitations of LIESEGANG" of STEMPELL a. o. (see p. 48-53).

2. To electric fields (see p. 53-57):
   a. electro-phoresis: exp. of SEIFRITZ a.o. (see p. 53-54).
   b. agglutination exp. of DE KRUIF and NORTHROP (see p. 55-57).
3. To magnetic fields (see p. 57):
   a. due to ionic action (see sensitivity of solutions, p. 81).
   b. due to magneto-chemical action (see sensitivity of solutions, p. 82).
   c. due to magnetic directive forces: exp. of SEIFRITZ, FREUNDLICH and GRIESZMEYER (see p. 57).
4. To electro-magnetic waves (see solutions, p. 62-73).
5. To temperature.
6. To chemicals (see p. 57-60):
   a. due to agglutination (see p. 55).
   b. due to chemical action of metals (see p. 57-60).
7. To radioactive matter (see p. 65).

C. Sensitivity of solutions (see p. 60-96):

1. electrolytes (see p. 60-96):
   a. to electric fields: electro-osmosis; electrolysis (see p. 60-61).
   b. to electro-magnetic waves and radio-active radiation: exp. of LEA, SUMMERS and HUGHES, DESSAUER, GRAY a.o. (see p. 61-73).
   c. to magnetic fields (see p. 73-85):
      α. due to ionic movements; exp. of URBASCH; PIERUCI; WILSON; TOWNSEND and TIZARD; DE VITA and MABY (see p. 81-82).
      β. due to chemical action: exp. of STSCHUKAREFF; PISSARSHEWSKY and ROSENBERG (see p. 82).
   d. to homoeopathic concentrations: exp. of KOLISKO; KRAKOW; HINSDALE; STERN; BOYD, a.o. (see p. 86-93).
   e. to meteorological and (or) cosmic influences (see p. 93-95):
      α. capillarity exp. of KOLISKO (see p. 94-95).
      β. waterfall-effect of MCADIE during thunderstorms (see p. 95).
      γ. crystallization exp. of PFEIFFER (see p. 95).
      δ. surface pot. exp. of BURR (see p. 94).
      ε. blood measurements of ALVAREZ (see p. 94).

2. gas solutions (see p. 96):
   a. to temperature.
   b. to atmospheric pressure: embolism.

II. Sensitivity of the total structure of the combined cell-components to physico-chemical influences (see p. 96-123).

A. In plants (see p. 96-101):

1. Tropisms: exp. on phototropism (heliotropism, Hertzotropism), geotropism, chemotropism, traumatotropism, haptotropism (thigmotropism), radiotropism, magnetotropism (see p. 96-99).
2. Nastic movements: exp. on thermonastics, photonastics, nyktinastics, chemonastics, seismonastics, traumatonastics (see p. 100-101).

B. In animals and man: sensitivity to (see p. 101-123):

1. Chemical excitations (sense of smell and taste) (see p. 101-106).
2. acoustic waves (auditory sense); supersonic waves (see p. 106-112).
3. excitation by electro-magnetic waves (see p. 112-121):
   a. light-waves (visual sense) (see p. 112-117).
   b. Hertzian-waves (exp. of CAPES, MABY a.o.: see p. 65-66, 68).
   c. temperature (see p. 117-121).
4. magnetic excitation (see p. 121-122):
   a. exp. on nerve-induction currents (of HERMANN, DANILEWSKY, SCHIFF and GRANDIS; see p. 121-122).
   b. exp. on muscular contraction (of TROMP; see p. 311).
5. electric excitation (see p. 122):
   a. nerves:
      α. by direct contact.
      β. by induction (exp. of GENGERELLI and HOLTER).
   b. muscles:
      α. directly.
      β. indirectly.
6. Mechanical pressure (sense of touch) (see p. 123).

III. Summary of energetic conditions of "life" required for existence on earth (see p. 123-125).

This table does not include all the phenomena which indicate the extraordinary sensitivity of the living organism. A complete list would not be within the scope of this publication. Even a short discussion of the above-mentioned experiments might be considered superfluous. It is nonetheless apposite to give some sort of summary as a thorough knowledge of the problem not only facilitates the understanding of the following chapters, but will prove to be the key to the last chapter, i.e., the explanation of the divining phenomena.

IA: Sensitivity of organic crystals to physico-chemical influences

IA. 1. Fluid crystals (see Bibl. No. 95-108)

Amongst the crystalline substances in living organisms a very interesting group occurs known as fluid or liquid crystals (see p. 9). Whereas ordinary crystals are defined as "homogeneous, discontinuous media mostly with anisotropic physical properties, mostly solid and bound by plane surfaces", the fluid crystals can be defined as follows: "they are homogeneous, chemically pure compounds, which show within a certain temperature-interval characteristics of a fluid; but at the same time they possess anisotropic properties such as birefringence; they have no limit of elasticity". They were discovered in 1889 by OTTO LEHMANN (see Bibl. No. 101-103), a German physicist.

Up to 1889, it was not considered possible that crystalline fluids could exist as in crystals the same physical properties occur in all parallel directions which seemed to be excluded in a fluid. However, in 1889 F. REINITZER studied *cholesterilbenzoate* ($C_{27}H_{45}C_7H_5O_2$) and discovered that it had two melting points. At 145.5°C it melts into a cloudy fluid; at 178.5°C it becomes a clear transparent fluid. LEHMANN studied the fluid in polarized light and discovered that between 145°C and 178°C the cloudy fluid shows birefringence phenomena, above 178°C it becomes transparent and optically isotropic. With the cooling of the fluid bluish white anisotropic spots suddenly originate, which become more and more abundant until finally the whole fluid is cloudy again. If the cooling is continued the fluid crystallizes and finally becomes a solid crystalline mass.

LEHMANN's studies were continued by VORLAENDER a.o. According to VORLAENDER the anisotropic properties of the fluid crystals require a linear structure of the molecules. Up till now only organic substances are able to form fluid crystals, as only in organic compounds is it possible to form the large molecules. The pronounced linear development of the molecules explains the optically uni-axial structure of fluid crystals. More than 200 organic compounds have so far been discovered that are able to form fluid crystals. They all possess two melting points. The longer the molecules of these compounds the more anisotropic their behaviour.

The anisotropic spots in fluids forming fluid crystals have different morphology: globular and polyedric forms are known. If the cohesion forces are larger than the crystallization forces, according to the law of minimum free energy, the crystalline bubbles take the shape of a globe. However, if the crystallization forces are the largest, polyhedral forms originate. The globular forms (e.g., in para-azoxyphenetol) are called *fluid crystals* and the polyhedral forms (e.g., in ammonium oleate) *flowing crystals.*

The fluid crystals are of particular importance in the living world, as phenomena occur such as movements, growth, division, etc., which are generally unknown in the inorganic world. For example, if two crys-

talline drops touch each other, they will unite and for a short moment two nuclei can be seen. Large crystalline drops might break into two parts, each of which will form a new globe. Flowing crystals (e.g., pyramidal) are able to unite after collision and grow out into a larger pyramid.

The fluid crystals in the cell, known as micellae (see p. 9) are influenced by three kinds of external fields: magnetic fields, electrostatic fields and electro-magnetic fields (waves). The magnetic influence is known as the FARADAY-*effect* (see also p. 80). In ordinary crystals the plane of polarization of rectilinear polarized light turns in a magnetic field until it is parallel to the direction of the magnetic lines of force. This is due to the electro-magnetic forces between the atoms and ions in the crystalline space-lattice structures. In a magnetic field the globes of fluid crystals will also turn till the axes of symmetry are parallel to the lines of force.

The influence of electro-static fields is known as the KERR-*effect*. The causes of electric charges of the micelle crystals have been discussed on p. 9. Surrounding electric fields have a directing influence on those fluid crystals both internally and externally. The internal changes consist of deformations in the space-lattice structures of each of the fluid crystals separately. The external influence consists of movements of the electrically charged particles (*electrophoresis*).

Crystals are also sensitive to electro-magnetic waves (see also p. 61-73); this is particularly shown by the so-called *luminescence phenomena*. Four groups are distinguished: *photo-luminescence* (*phosphorescence* and *fluorescence* respectively, i.e., emission of light due to previous irradiation of crystals with light waves, which in the case of fluorescence occurs only as long as the irradiation takes place; in case of phosphorescence it persists after the exciting source is shut off), *electro-luminescence*, *thermo-luminescence* and *tribo-luminescence*, the three latter occurring in an electric field, after heating or breaking of crystals respectively.

It is known that the wavelength of the light emitted by a *fluorescent* substance is usually greater than that of the exciting radiation (STOKE's *law*). There are, however, exceptions. The phenomenon is due to primary absorption of electro-magnetic energy by the atoms or molecules of the crystal space-lattices raising the physical state of the atom, and to the secondary release of part of this energy. As this energy is smaller than the absorbed quantity, the emission energy must be smaller and the wave-length larger. This phenomenon is created particularly by irradiation with X-rays and ultra-violet light, but does not occur with infra-red.

However if the atoms or molecules possess a surplus of energy the law of STOKE does not work and the so-called *anti*-STOKE's *lines* or the RAMAN *effect* are created (see p. 102).

IA. 2. Crystallizing solutions (see Bibl. No. 109-136)

The great sensitivity of crystallizing solutions to physico-chemical forces, and therefore also the formation of micelle structures, can be demonstrated in different ways:

OSWALD has shown that supersaturated solutions suddenly start crystallizing if 10^{-10} gr of salt is added to the fluid. The crystallization processes in normally crystallizing fluids are determined by the chemical and physical properties of the motherlye and its surroundings, the most important physical factors being temperature and pressure. Local differences in temperature create differences in saturation of the fluid, microconvection currents, changes in viscosity, which again influence the convection currents, etc. The speed of these changes is very important, as are the physico-chemical conditions of the motherlye. WEYBERG could show the influence of the pH *factor*. Alum crystallizes in a neutral solution as octahedrons, in alkalic solutions as cubes. The chemical composition determines local physical conditions such as capillarity, cohesion forces between molecules, etc.

LEHMANN demonstrated the influence of the *diffusion currents*; it is strongest near the corners and edges of crystals.

LEHMANN, WULFF, and MIERS could show that very close to the crystal faces the fluid is always supersaturated, creating the so-called *concentration currents* which are important for the formation of *vicinal crystal faces* (i.e., very steep planes, characterized by high rational indices).

RAUBER made some experiments which show the great *regeneration capacity* of crystals. An alum octahedron, polished into the shape of a globe and placed in a supersaturated alum solution, quickly rebuilds its original structure by developing new plane octahedron and rhombic dodecahedron crystal faces, etc. LAVIZARRI, GOLDSCHMIDT, WRIGHT, MEYER, PENFIELD, and GILL demonstrated the extremely great regeneration capacity of crystalline substances, a property often erroneously attributed to living bodies only. PFEIFFER showed the influence of traces of organic compounds on crystallizing fluids. A 25% solution of copper chloride was used and drops of organic plant saps or blood of different animals were added. Completely different crystal associations were obtained characteristic of the particular type of plant or animal*.

The phenomenon of *polymorphism* (i.e., the phenomenon that a crystal can appear in more than one modification, similar to the phenomenon of *allotropy* in chemistry) indicates the sensitivity of crystalline bodies to external forces. Two kinds of polymorphism are known: there is a change either in the external form, due to different physico-chemical conditions (e.g., carbon crystallizing either as diamond or as graphite), which is only possible in the fluid state, or in the internal structure of the spacelattices. Examples of the latter are the minerals leucite and aragonite. *Leucite* (SiO_4. SiO_2) AlK crystallizes above 620°C as isometric crystals, below 620°C the outer form remains but the internal structure changes into an orthorhombic crystal. *Aragonite* ($CaCO_3$), with a rhombic

* Applications of this method on Cancer research are described by Dr MARY L. QUAIFE, in Bibl. No. 52, p. 907-909, with extensive bibl. references (see also p. 87).

bipyramidal structure, changes internally above 400°C into calcite with hexagonal rhombohedral properties.

Crystals possess an *inductive influence* which has been erroneously attributed by biologists to the living organisms only. A good example is calcium carbonate which crystallizes either as *calcite* (hexagonal rhombohedrons) or as *aragonite* (rhombic bipyramids). Calcite originates in pure solutions below 29°C, aragonite above 29°C. However, a trace of a calcite crystal brought in an aragonite solution above 29°C creates the formation of calcite crystals. In other words it induces calcite properties.

These are characterized by different elements of symmetry leading to different twin-crystals, different crystal faces (almost 750 combinations are known of calcite), different colouring with a boiling cobalt nitrate solution (so-called test of Meigen: calcite remains white, aragonite becomes violet), different solubility in water (aragonite: 19 mg in 1 litre water, calcite 13 mg in 1 litre water of 18°C), different hardness (aragonite: 3½-4, calcite: 3), different specific gravity (aragonite 2.9-3; calcite: 2.6-2.8), different solubility in acid (aragonite is less soluble), etc.

Also aragonite could induce its properties. Below 29°C, in the presence of magnesia (or other compounds) aragonite fragments are able to create aragonite crystals in the calcite fluid.

Finally, the presence of alcalic compounds in a fluid above 29°C creates not aragonite but the spherolitic crystals of *Vaterite*. Certain conditions change calcite into a monoclinic phase called *Lublinite*.

This brief summary of the most important physical properties of crystalline substances and the abundance of crystalline bodies in living matter explains the great sensitivity of living matter to physico-chemical influences.

IB. 1: Sensitivity of colloidal substances to volatile matter

(see table p. 26)

We have seen in section 1 on the structure of the cell that the extraordinary properties of the living cell are, for a considerable part, due to the colloidal structure of the proteins in the protoplasmatic fluid. The problem of the sensitivity of the cell can therefore be studied from this angle.

Two groups of experiments are known, which indicate the great influence of volatile matter on colloidal substances:

1. the experiments of R. Colson and W. J. Russell on the action exerted by certain metals and other bodies on a photographic plate (see Bibl. No. 148-150b);
2. the experiments of R. E. Liesegang, R. Fricke, W. Stempell, G. von Romberg, G. van Iterson, C. Homan van der Heide a.o. on rhythmic precipitations, so-called Liesegang figures (see Bibl. No. 137-155).

IB. 1. a: The photographic experiments of W. J. RUSSELL

Cause of discovery: In 1896, after the discovery of the influence of uranium on photographic plates by H. BECQUEREL, the uranium experiments were repeated in England by RUSSELL in the Davy-Faraday laboratory in London with a perforated zinc plate as a screen between the uranium and the photographic plate. He expected a clear picture of the different holes in the zinc plate. However, the reverse happened. The greatest amount of action occurred underneath the zinc. This experiment was repeated many times, without radioactive substances in the neighbourhood, and with different metals. The results were always the same and indicated that the metal action was not due to the radiation but to volatile matter given off by these metals. Independently, R. COLSON discovered in France, in the same year, that traces of volatile components of metals (such as zinc, cadmium and magnesium) cause disturbances in the colloidal substances of the photographic plate. The great importance of the discoveries was overlooked in a period of radioactive research, and though they are, in principle, still in use today the original experiments have been forgotten. As they are of great significance in the explanation of the divining phenomena we give a detailed survey of RUSSELL's experiments [1].

Composition of a photographic plate: when preparing a photographic plate silver bromide is first precipitated in water containing gelatine. Gelatine is a colloidal suspension of proteins in water, derived from the white fibres of connective tissues of the animal body (chemically known as collagen), especially the white connective tissue of the corium (true skin), the ossein of bone and the tendons. The photographic gelatins possess high jelly strength (200-225 g), pH value 5-6, moisture 8-15%. The mixture of gelatine and bromide is kept warm so that the precipitate becomes more sensitive to light by acquiring a coarser grain; it is applied to plates of glass or strips of transparent celluloid (films). The bromide after exposure is more easily reduced to metallic silver in proportion to the intensity of light. Development consists of applying a reducing agent of such slight activity that it only reduces the illuminated parts, e.g., potassium quinol $C_6H_4\,(OK)_2$ is used:

$$2\,AgBr + C_6H_4(OK)_2 \rightarrow 2\,Ag + 2\,K\,Br + C_6H_4O_2$$

The plate (negative) becomes most opaque where the original object was brightest, i. e., the illumination most intense. The positive is the reverse. Light of short wavelength, blue and violet, has greatest effect upon silver halides, the time in seconds required for equal effect in violet being 15, blue 29, green 37, yellow 330 and red 600.

The experiments of RUSSELL and COLSON are the more interesting as they were carried out with colloidal suspensions of protein-substances, which derive from living matter.

Originally the RUSSELL's *effect* was observed only with metals, but

[1] RUSSELL pointed out that only the most sensitive photographic plates, without extremely long exposures, give the above-mentioned results. The MAWSON plate has generally been used, but the ILFORD special rapid plate acts equally well.

many synthetic organic compounds, plants, etc., showed similar phenomena.

Evidence that volatile components are the cause of the photographic disturbance:

A. *The following experiments indicate that the action of metals is due to volatile components:*

1. *Influence of screening:* if thin mica plates are placed between the zinc and the sensitive plate a ring of action is produced on the plate which can only be accounted for by presuming a vapour is present and has worked its way between the mica sheets, which is inactive in itself. If a polished piece of zinc is used the action can be seen even in 4 to 5 hours.
2. *Inducing influence:* a piece of Bristol board can be made active by contact with, or mere proximity to, a piece of polished zinc. For example a piece of perforated zinc was placed on the bottom of an ordinary plate box for about two months; the zinc was then taken away and a sensitive plate dropped in its place. On developing the plate a picture of the perforated zinc was obtained.
3. *Reproduction of designs:*
   a. If a Bristol board is not in direct contact with the zinc but a screen, with holes cut out in it, be interposed, it will be found after 6 weeks that the parts of the Bristol board opposite the holes of the screen become active and will give an exact picture of the holes or other designs cut out on the screen. This experiment has so far been successful only with zinc but longer exposure than 6 weeks might reveal that the experiments could be performed with other metals.
   b. A slight pattern produced on zinc by pressing on it a piece of white net and then rubbing it down with fine emery or sandpaper will give a picture in which the pattern is evident even if the zinc is not in direct contact with the plate.
4. *Influence of absorbing agents:* two pieces of glass tubing, 1 inch long and $^3/_4$ inch wide, were taken by RUSSELL; a single coil of inactive paper was placed inside one of the tubes; both open tubes stood on a sheet of polished zinc and a photographic plate rested on the top of them. They were then left for a week and on developing the plate, a black patch appeared only above the tube without paper; no action was visible above the one with the paper. If the paper, without removing it, was painted over with melted paraffin and the experiment repeated, both tubes gave the same dark patches.
5. *Influence of air currents:* if an air current is passed through a 12-in. long glass tube and a photographic plate placed at the other end no signs of action can be seen even after a week. However,

if zinc turnings are placed in the tube and a stream of pure air passed through the tube for a week, a black patch is produced on the plate immediately above the end of the tube.

B. *The following experiments indicate that the action of organic compounds is also due to volatile matter:*

1. a. Russell found that printing ink and copal varnish are both active substances when in direct contact with a photographic plate and when at a distance from it. The action they exerted was able to pass through different media.
   b. The main constituents of these organic compounds are boiled oil (i.e., linseed oil which has been heated with lead oxide) and turpentine. Both constituents separately behaved in the same manner with photographic plates as did printing ink and copal varnish.
   c. If the varnish is heated first for a long time and all volatile components driven out, an inactive gum remains.
2. *Influence of adsorbing agents:* a thin sheet of gelatine offers only slight obstruction to the vapours of ink and copal varnish. If the thickness of the gelatine is increased the exposure time must be longer.
3. *Influence of screening:*
   a. a circular piece of Bristol board was saturated in drying oil and at little distance above it was placed a smaller circle of mica (which is perfectly opaque to the action); again above this was another piece of mica with a circular hole smaller than the underlying circular mica plate. The photographic plate was placed above the second piece of mica. The vapour worked its way between the mica plates and after three days a dark ring was formed, shading off towards the centre.
   b. A small circular glass dish, with some drying oil in it, was placed on a photographic plate and left there for a week. On developing the plate no action had taken place where the dish stood, but further outside much action had occurred.
4. *Inducing influence:* If a piece of Bristol board is suspended above drying oil, in the liquid or solid state, or above turpentine or picture copal, for two or three days (or even less) it becomes strongly active and when placed in contact with a photographic plate it quickly darkens it.
5. *Reproduction of designs:*
   a. If a pattern is stamped on the Bristol board before the previous experiment is started, a clear picture is obtained on the photographic plate. However, if the Bristol board, after being exposed to the vapours is kept in the open air for a day or two, its activity is mostly gone.

Similar ghostlike pictures can be obtained if, previous to the experiment, a drawing of a person is made on the board.

b. A hard copal surface on glass will give a picture showing every brush-mark, unevenness and scratch on the surface. The action takes place even through a thin sheet of gelatine and even through as many as 6 or more.

Different kinds of matter creating photographic action:

A. *Metals:* in addition to zinc, several other metals and alloys are able to produce photographic effects. The following is a rough list of active metallic bodies approximately in the order of their activity: magnesium, cadmium, zinc, nickel, aluminium, pewter, fusible metal, lead, bismuth, tin, cobalt, antimony, mercury (practically inactive). Although Cd and Mg are slightly more active than Zn, the latter is most convenient for experiments. Mercury sometimes is very active, but only when impure. Zinc which has been exposed for a long time to the air is inactive. Smooth metal surfaces are active, but the greatest activity is obtained (within 5 hours) after rubbing the surface with coarse sand or emery paper; if cleaned with acid or caustic alkali it is less active.
Only a few alloys have been experimented with by RUSSELL: brass (containing 20% Zn) is inactive, but pewter (mixture of 75% Sn and 25% Pb) and fusible metal (Pb, Sb, Bi) are very active. Brass (containing 40% Zn), bronze (containing 3-8% Sn, 11% or more Zn and some lead) were not tested but are most likely active.
Oxides and sulphates, both of zinc and cadmium are completely inactive. Iron, gold and platinum are practically inactive and copper only slightly. These statements are based on experiments by RUSSELL which lasted for one week. Longer trials might show that other metals are active too.

B. *Organic compounds:*

1. Vegetable oils: linseed oil and turpentine, the main components of printing ink and copal varnish, are very active; olive oil only very slightly active; damar and Canada balsam are active.
2. Essential oils: peppermint, lemons, pine, juniper, bergamot, winter green, lavender, cloves, eucalyptus, and cajeput were all found to be active, also when dissolved in a large amount of pure alcohol. Characteristic components of the essential oils are the *terpenes* ($C_{10}H_{16}$), the principal component being *pinene* ($C_{10}H_{16}$), which occurs not only in all pine trees but in the essential oils of eucalyptus, laurel, lemon, juniper, parsley, sage and thyme. Other important components are *limonene, terpinolene, phellandrene and sylvestrene* (all monocyclic terpenes); *camphene* and *bornylene* (together with pinene belonging to the dicyclic terpenes).

3. Paraldehyde $(C_2H_4O)_3$ and benzaldehyde (C_6H_5CHO) are very active. Formaldehyde (HCHO) is only slightly active. The important property of these bodies is their reducing (or oxygen absorbing) power, hence the conclusion by RUSSELL that it is this property that enables them to act on the photographic plate.
4. Resins and allied bodies can, when used alone, be very active; e.g., ordinary resins, Burgundy pitch, gum mastic are very active, asphaltum and dragons blood much less, but true gums such as gum senegal and gum arabic are entirely without action.
5. Mineral oils, purified petroleum spirit, alcohol, ether, the esters such as ethyl acetate, benzene, nitro-benzine, carbon disulphide, chloroform, sugars, etc., are all inactive when pure. Oxidized bodies related to the terpenes, such as terpinol and camphor, are not active.
6. White paper is inactive; ordinary strawboard (e.g., of pill boxes) is very active. The activity of printing ink (see p. 35) explains the activity of many newspapers.

   The importance of the oxygen-absorbing influence of the active organic compounds is shown if we compare linseed and olive oils.

   Linseed oil is very active, 1 g being capable of absorbing 186 ml of oxygen; olive oil is only slightly active and 1 g can absorb only 8.2 ml of oxygen.

C. *Inorganic compounds:*

1. Pure water does not act on a photographic plate if placed above it.
2. Salts of zinc are inactive.
3. Paper soaked in solutions of alum, potassium chromate, zinc sulphate and quinine sulphate are inactive.
4. Coal, coke and sulphur are inactive.

D. *Living matter:*

1. RUSSELL discovered that any ordinary smooth piece of wood laid on or at a little distance above a photographic plate, will act on it. Further investigations revealed that certain woods are much more active than others. In order to obtain good effects the experiment should last half to eighteen hours at a temperature below 55°C.
2. The activity of wood is increased by the presence of moisture (water in itself is inactive, see C 1); if it is painted with melted paraffin it is no longer active.
3. a. A piece of mahagony, 3.5 mm thick, kept in this form at least 35 years in a dark cupboard, gave a good picture after a week's exposure. The bottom of an old cigar-box acted equally well.
   b. An oak box a hundred or more years old was found to be still active.

4. Ordinary charcoal depicts itself on a plate, but if it is heated for hours in a covered crucible it loses this property.
   A piece of wood charred on one side by means of a Bunsen burner becomes remarkably active. The action passes through gelatine, parchment, etc., and the structure of the wood can still be seen.
5. The wood of conifer is very active:
   a. A section of a young larch tree showed clearly the rings and the layer of bark. The dark rings in the wood are active, the light coloured inactive. The same action is obtained if a layer of gelatine is placed between the wood and the plate.
   b. The Scotch fir shows the opposite. The light coloured rings of spring are very active and produce dark rings in the photographic plate (see fig. 2); the dark rings are inactive, although they are resinous.
   c. The wood of spruce-fir is less active.

Fig. 2: (Bibl. No. 150) Russell effect created on a photographic plate by a branch of a Scotch fir, showing rings of spring and autumn growth, the former producing the dark rings.

6. Wood of oak, beech, acacia, Spanish chestnut and sycamore are active.
   On the other hand, ash, elm, horse chestnut and plane are only slightly active.

7. Woods outside Europe are often very active, but lack of annual rings makes the pictures less clear. For example, African blackwood, rose-wood, cocobola and many others are very active.
8. Knots in a wood generally, though not always, give a good picture. The resin in contact with the knot is in some cases only slightly active.
9. In certain cases the pictures obtained from wood do not resemble the markings visible on the wood. These pictures are persistent in the wood, shown by fresh sections giving the same result.
10. Other vegetable substances are active: hay, straw, bamboo, etc.

Different kinds of matter preventing the Russell *effect*:

A. Inorganic Compounds:
Thin glass, selenite and mica, even in very thin layers, prevent any photographic action, both of metals and organic compounds.

B. Organic Compounds:
1. Gelatin, celluloid, colloidon, guttapercha tissue, tracing paper, parchment and ordinary paper are more or less transparent for the volatile matter of the Russell effect, both in case of metals and organic compounds. These experiments are also instructive in connection with Stempell's experiments (see p. 22 and 49). It is doubtful whether his cellophane could be considered to be airtight.
4. Arabic gum or paraffin are opaque.
3. Paper, in itself transparent, is quite opaque if soaked in solutions of alum, potassium chromate, zinc sulphate and quinine sulphate. This might explain the fact that certain writing papers are opaque to the action of zinc.

In order to gain further knowledge of the diffusion properties of different substances, the power of hydrogen to diffuse through them was tried by cementing specimens of the different substances on glass tubes filled with hydrogen and placed over water.

With thin gelatin ordinary diffusion did not at first occur (the water in the tubes hardly rising), though there was a reaction after a few days, after a week the level of the water about 4 inches higher in the tube than outside.

With thick gelatin no evidence of any diffusion occurs. Celluloid and tracing paper act in the same way as gelatin. With gutta percha the tube fills up completely with water.

The rise in water is not only a question of absorption of hydrogen. A considerable quantity of gelatin in a tube sealed at one end, filled with hydrogen and inverted over water did not show any rise of water level, even after weeks. Metallic volatile matter, either because of its finer molecular state or its influence on the permeability of membranes (see p. 17), can diffuse through an air-tight medium.

Influence of the concentration of volatile matter:

Increase of zinc plates in a glass dish below a photographic plate increased the action on the latter, but only if holes in the zinc also allowed the volatile matter of deeper layers to escape. Otherwise no difference was observed.

Influence of impurities:

It is remarkable how traces of impurties can change inactive into active substances.

1. Pure water, alcohol or ether are inactive, but only after serious digestion with lime and careful distillation.
2. A trace of zinc in pure alcohol makes it active. The same happens with ether and ethylacetate, but not with benzene. Only zinc, cadmium, magnesium, aluminium and fusible metal appear to create this effect.
3. Less than 1/300% of zinc in mercury makes it one of the most active metals. Magnesium and lead have the same influence.

Influence of temperature:

1. Increase in temperature of metals such as zinc or nickel greatly increase the action. After 5 hours the heated zinc (at 70°C) gave a black picture, at 8°C no activity was observed.
2. Increase of temperature of organic compounds generally increases their activity. Heating of copal in a water bath deprives it of a considerable amount of its activity, but this can be revived by wetting it with ether and drying at ordinary temperatures.

Influence of atmospheric gases on the RUSSELL *effect:*

1. Aqueous vapour is inactive.
2. The effect of zinc on a photographic plate in hydrogen or ordinary air is similar.
3. Carbon dioxide produces a greater effect, probably due to its action on the zinc plate.

Influence of electro-magnetic waves:

1. RUSSELL tried to show the possible wave character of the RUSSELL effect. A very active zinc plate was placed in front of a glass and possible rays were reflected on a photographic plate. No result was obtained even after a fortnight, a marked difference from radioactive substances.
2. The influence of the colour of the absorptive medium was also studied. A mere difference of colour did not alter their absorptive capacities. Thin sheets of gelatin, whether red, green or blue, influenced the RUSSELL effect in the same way.
3. a. RUSSELL discovered that the activity of wood greatly increased

after it has been exposed to strong white light. If a piece of deal is half covered by black paper or tin foil and exposed for 5-10 min to bright sunlight it will give a dark picture where the light has fallen (see fig. 3).

b. Even comparatively inactive woods such as elm and ivy, after a short exposure to bright light, give dark pictures.
c. This increase of power of wood by action of light decreases rapidly after the first 24 hours; the decrease slows down, and a fortnight or a month elapses before the wood resumes its former condition.
d. This action stops entirely by interposing the thinnest piece of glass or mica between photographic plate and wood.
e. An inactive card painted with an alcoholic solution of resin becomes very active after exposure to bright light.
f. Bodies other than those which may contain resin or allied substances are not affected by light; e.g., flour or sugar are inactive.
g. Metals are not rendered active by sunlight.
h. The action of monochromatic light varies with the wave-length. Red and green light does not increase the activity of wood. Blue light increases the action similar to white light.

Explanation of the RUSSELL *effect:*

We have discussed the experiments of RUSSELL at length as they are of the greatest importance for the understanding of a group of divining phenomena known as *radiesthesia* (see p. 369, ch. III).

The experiments on p. 34 and 35 indicate that the RUSSELL effect is caused by volatile matter and not by a radiation. The experiments with reflecting mirrors, mentioned above, which gave a negative result and the inactivity of salts of zinc, etc. (great contrast with uranium salts etc.), support this conclusion. Whereas in case of organic matter the explanation is relatively simple, it is difficult to understand the actual cause of the metal activity. We shall therefore consider both cases separately.

Cause of emanation of volatile matter by metals

Two kinds of volatile matter can be expected: metal atoms (or ions) or chemical compounds released after previous absorption.

1. *Possibility of extruded metal atoms:*

It is well known that electro-magnetic waves can create a *photo-electric effect* (see p. 64). Actual emission of atoms or ions does not occur however. The above-mentioned experiments of RUSSELL, which show no increase in activity if a metal is irradiated seem to exclude a photo-electric phenomenon either by sun or cosmic rays.

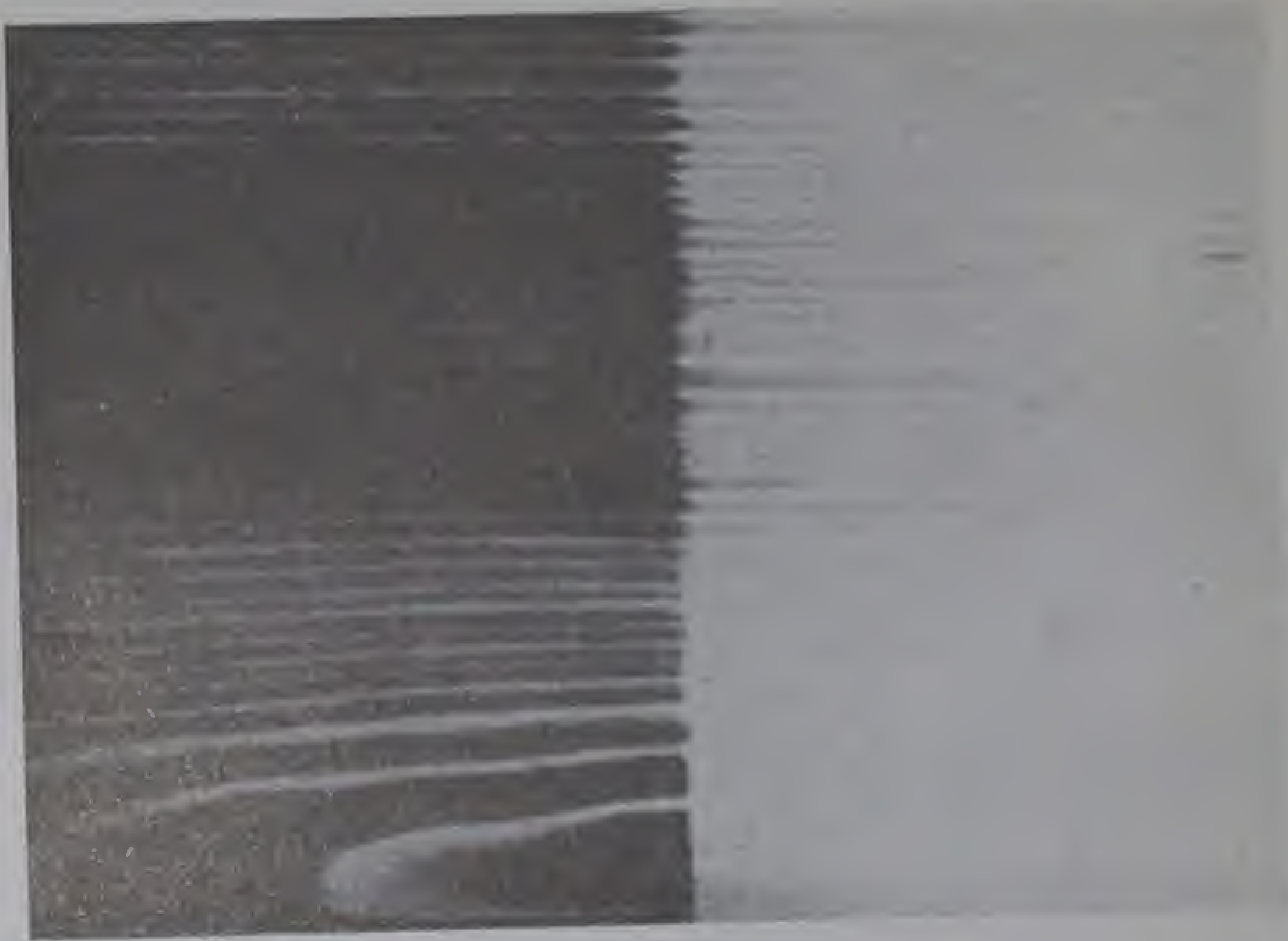


Fig. 3A: (Bibl. No. 150). A piece of deal half covered by black paper and exposed for 5-10 min to bright sunlight and then put up with a photographic plate. The non-covered part gave a dark picture.

In order to discuss the other causes of metal action we must first analyse the main causes of blackening of a photographic plate:

a. all electro-magnetic light-waves, X-rays, cosmic rays and radioactive rays:
b. mechanical pressure;
c. heating;
d. electric fields (disturbing the electrically charged colloids);
e. currents of ions;
f. contact with reducing chemical agents;
g. contact with radioactive substances.

It seems that only e, f and g might be of importance; e.g., we could think of a photo-electric or cosmic ray action on the metals creating an increased ionization due to electron emission above the metal. However, the induction experiments, experiments with screens, etc., even at a certain distance from the plate, make this possibility improbable, though it must still be kept in mind. The effects mentioned under f could be caused by a chemical reaction on the surface of the metal, thus creating volatile reducing agents. However, most of the metal salts are not volatile and do not necessarily have a reducing effect.

Radioactive action could be caused by traces of radioactive material,

either finely distributed in the metal or concentrated in pores and fissures. However, the former case is excluded from the induction experiments of RUSSELL; the latter is possible, but difficult to visualize as the metal would obtain the volatile radioactive components (e.g.,

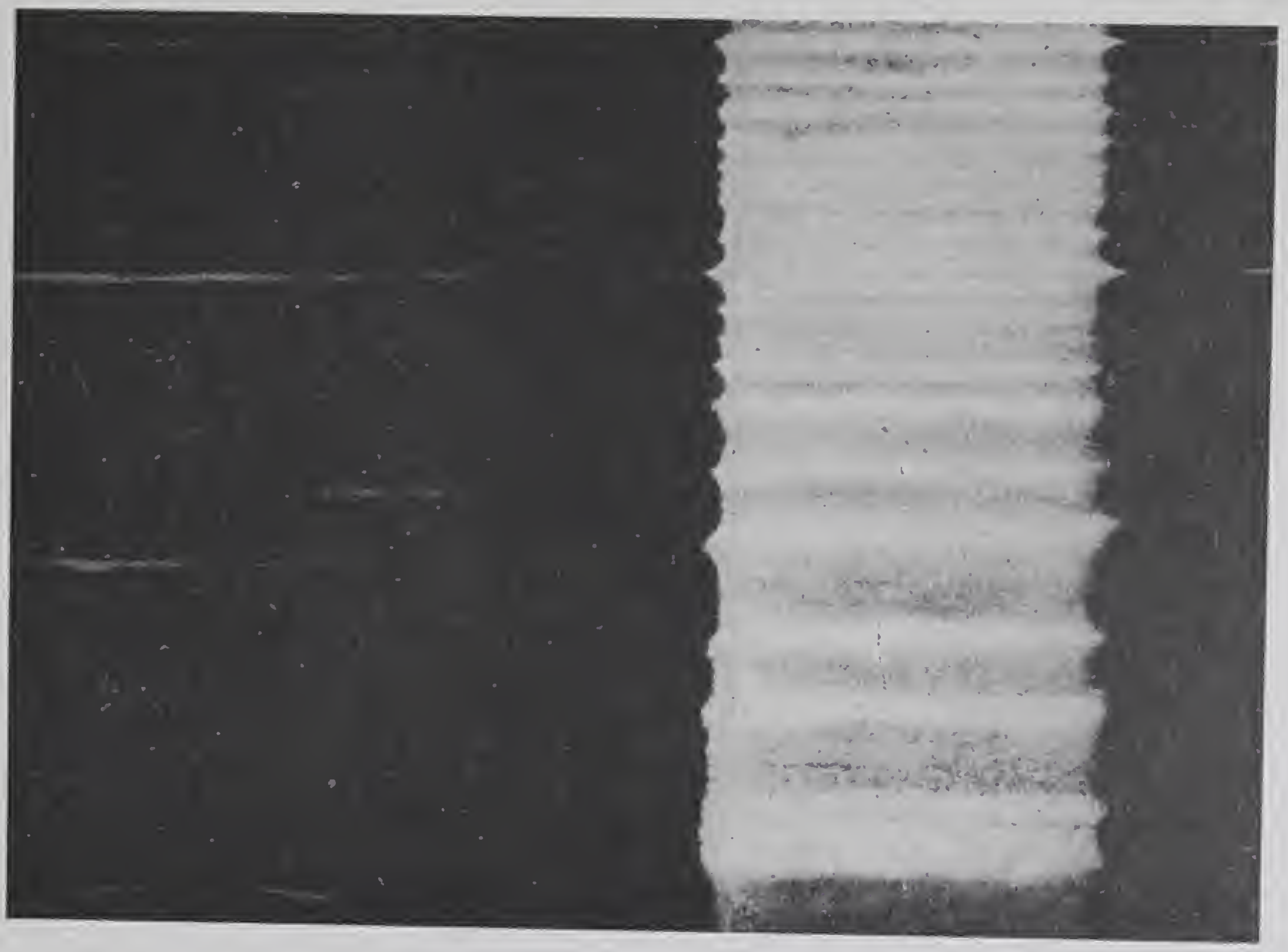


Fig. 3B: red and white glass was placed on the wood. Dark left side of picture was covered with white glass; middle part with red glass; right side without glass. Picture indicates influence of infra-red.

radium or thorium emanation) through the atmosphere (or the air in the soil). But we have seen that an air-current alone does not influence a photographic plate. Still, in certain instances this might be the cause of metal activity. In general however, it seems more likely that the action is due to the physico-chemical action of volatile components occluded in the surfaces of metals and other bodies.

2. *Possibility of extrusion of volatile chemical compounds:*

Two kinds of physico-chemical phenomena must be reviewed in order to understand the following discussion. In the first half of the 19th century GRAHAM, a British chemist, studied the relation between gases, fluids and solids. He distinguished adsorption and absorption. *Adsorption* is the taking up of gas molecules into the surface layer of colloid bodies. If this process spreads into deeper layers, it is called *absorption.* According to the second main law of thermo-dynamics (law of minimum free energy) those solutes will be concentrated or

adsorbed at the body surface which lower the surface tension of the liquid or solid. The amount of adsorbed gas is directly proportional to the surface of the adsorbing medium and the concentration of the gas. The adsorption capacity generally decreases with increasing temperature, but the rate of adsorption increases. Absorption in fluids increases with increasing pressure and decreases with rising temperature. Local changes in temperature or pressure create locally supersaturated gas solutions.

A special form of adsorption is called *occlusion*, i.e., the property of many metals to adsorb great quantities of gases, in particular hydrogen.

Palladium, for example, at 15°C could adsorb a quantity of hydrogen 850 times its own volume, in colloidal suspension even 1,200 times. The amount of occluded gas is directly proportional to the square root of the hydrogen pressure. Not only palladium but also platinum, nickel, iron and carbon have great occlusion capacities, which means at the same time a very small effusion capacity of adsorbed gases.

The laws of adsorption explain that bodies with a great inner surface such as coal, kaoline, etc., have great adsorption capacities. For the same reason colloidal substances have a great adsorbing power.

Adsorption of a salt is an additive property of the cation and anion. The order of adsorbability of cations is as follows: basic organic dyes, H, Ag, Hg, Cu, Al, Zn, Mg, Ca, NH_4, K, Na; for anions the order is OH, CN, S, I, NO_3, Br, Cl and SO_4. So, apart from organic dyes, H and OH ions are the most readily adsorbed. In case of metals their valency and position in the so-called *electromotive series* are of great importance. This series indicates for different metals their ability to displace those following it in the list and is as follows: Li, K, Na, Ba, Ca, Mg, Al, Mn, Zn, Cr, Fe, Cd, CO, Ni, Sn, Pb, H, Sb, Bi, As, Cu, Hg, Ag, Pt, Au. The series indicates:

1. the order of diminishing tendency to enter the ionic from the elementary condition; the higher a metal stands in the list, the more readily will its atoms assume the ionic state;
2. the order of tendency of the free elements to lose electrons;
3. the capacity to displace hydrogen from dilute acids and water; all metals above hydrogen can displace hydrogen, those following it in the list are unable to produce hydrogen;
4. the rate of abundance in nature; metals preceding hydrogen rarely (or never) occur uncombined in nature; the following do.

Due to 1 and 2 the potential differences produced by metals in a salt solution are as follow: Li(—3.02), K(—2.92), Na(—2.72), Ba(—2.8), Ca(—2.5), Mg(—1.55), Al(—1.34), Mn″(—1.0), Zn(—0.76), Cr‴(—0.6), Fe″(—0.43), Cd(—0.40), Ni(—0.22), Sn(—0.14), Pb(—0.13), H_2(0.00), Sb(+0.1), Bi(+0.2), As(+0.3), Cu″(+0.34), Hg(+0.79), Ag(+0.80), Hg(+0.86), Au(+1.5). The potentials of the metal electrodes are compared with the potential of a platinum electrode, saturated with the hydrogen gas under 1 atm pressure, against a "normal" solution. The sign preceding the number is the charge of the free metal. It will be seen that the most electro-positive metals acquire the highest negative potential in consequence of their extreme tendency to throw off positively charged ions.

The electro-motive series furnishes a key to all actions involving solutions in which a free metal is used or produced; we have dealt with this because both the present and following problems can be understood only with these facts in mind.

The experiments on the GURWITSCH and STEMPELL effect (see p. 49) demonstrated that according to research workers, irrespective of their

opinion of the GURWITSCH radiation, living matter emanates (either accompanied by an electro-magnetic wave or not) volatile components, which are able to pass membranes and can act on colloidal substances even without direct contact. It is therefore logical to assume that the action of metals is also caused by a similar phenomenon. The metals are able to adsorb or produce chemical compounds which, after being released, have either a reducing effect on the photographic plate or can disturb the stable condition of the colloids on the plate. We have seen that colloids in particular have a great adsorbing power for gases; this considerably facilitates both processes. The main compounds responsible for the action of metals are probably *hydrogen* and organic compounds with reducing capacities such as *terpenes*. The success of hydrogen activity depends on the following factors:

1. the metal must be able to adsorb or produce great quantities of hydrogen in its pores or fissures;
2. the hydrogen must be easily releasable (metals with great occlusion capacity are inactive);
3. the objects in the neighbourhood must have a great adsorption capacity for hydrogen; in particular colloidal substances or material with many pores (cardboard, photographic plates) are favourable (see also p. 62 and 65 influence of protons).

Sub. 1.: Let us consider first the *capacity of metals to adsorb hydrogen.* It is well known that ordinary heating gas, so-called *water-gas*, is obtained when steam is passed over white hot coke or anthracite, giving a mixture of carbon monoxide and hydrogen ($C + H_2O \rightarrow CO + H_2$). In illuminating gas, however, the water-gas is carburetted by adding unsaturated hydrocarbons, particularly ethylene (C_2H_4). The water-gas for this purpose passes strongly heated bricks on which oil is sprayed, the oil being cracked at high temperature. The condensable hydro-carbons are washed out but in the water-gas acetylene ($C_2H_4 \rightarrow H_2 + C_2H_2$) and other hydrocarbons also originate; the acetylene is often reduced again into carbon and hydrogen. As a result the heating gas burnt in houses and factories contains abt. 8.9% ethylene (and other compounds), 10.2% methane, 40.5% hydrogen, 34.0% carbon monoxide and 6.4% impurities (N_2, CO_2, etc.). As not all the gas burns completely the atmosphere in rooms, where gas is often burning, always contains traces of hydrogen which is adsorbed by substances which have great adsorption capacity.

The presence of oxygen is of no importance. When oxygen and hydrogen are mixed in a bottle, the chemical reaction is very slow at ordinary temperature. Even in a mixture sealed up and kept at 300°C only a very small part of both components will combine even after several days; this is contrary to the general belief of non-chemists.

Metals can also produce hydrogen:

a. potassium, natron and calcium produce hydrogen in great quantities in cold water; $2K + 2H_2O \rightarrow 2KOH + H_2$; $Ca + 2H_2O \rightarrow$

$Ca(OH)_2 + H_2$. Iron, zinc and magnesium develop hydrogen only with steam for a short time. Ag, Au, Pt, Cu and Hg are unable to do this even when heated in steam.

b. Zinc, iron and aluminium displace hydrogen from diluted acids, e.g.:

$2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$
$Zn + 2HCl \rightarrow ZnCl_2 + H_2$
$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
$2Zn + CO_2 + 3H_2O \rightarrow Zn_2(OH)_2CO_3 + 2H_2$
$Zn + 2H_20 + 4NH_3 \rightarrow Zn(NH_3)_4(OH)_2 + H_2$

The atmosphere always contains traces of these different diluted acids and it is therefore possible that the above-mentioned reactions occur, the produced hydrogen being occluded by the metal. The neighbourhood of substances with greater adsorption capacities (colloidal substances) could free those gases in the metal.

c. Contact of zinc with less electro-positive metals such as Pb, Fe, Cu or Pt or contact of iron with inactive metals such as Cu and Pt create electrical couples and hasten the development of hydrogen. Thus commercial zinc, which always contains traces of other metals (Fe, Pb, Cd, etc.) gives a steady evolution of hydrogen if placed in water, while extremely pure zinc is almost inactive. 65.3 parts by weight of zinc gives abt. 2.0 parts by weight of hydrogen, i.e., 1 lb. of zinc gives abt. half an ounce of H_2.

Hydrogen originates also as a by-product in the electrolysis of an aqueous solution of sodium chloride. Electro-chemical currents in the neighbourhood of metals (also the electric potentials in living tissue, see p. 8, and on the surface of the skin and the presence of NaCl in the tissues and on the skin of living organisms, etc.,) could explain the development of traces of hydrogen. Hydrogen found in small pockets of rock-salt deposits in nature was probably formed by a similar process.

Sub 2. (see p. 45): The hydrogen and other reducing gases in metals must be easily releasable and should be able to reach other adsorbing agents in the neighbourhood in a sufficiently short time. The average diffusion speed of hydrogen molecules at room temperature is 1,840 m/sec, of oxygen only 460 m/sec. *The diffusion rates of different gases is inversely proportional to the square root of the density of the gas* (law of GRAHAM 1829). But *also the effusion of gases through fine tubes follows the same laws* (according to GRAHAM).

Two other important phenomena must be recalled: *the chemical activity of gases varies considerably with changes in their concentrations.* A constant gas-current will produce more regular physico-chemical changes. *The diffusion takes place under normal conditions in straight lines,* particularly if the emanating body is separated by air from a strongly adsorbing agent such as a photographic plate. This phenomenon can give the impression of a radiation phenomenon.

Sub 3.: The adsorbing power of the objects in the neighbourhood of metals must be great in order to produce the RUSSELL effect. Colloids are the most favourable. Preferential adsorption of positive H and negative OH ions gives the adsorbent a positive or negative charge, which explains the origin of electric charges on colloids; but the agglutination of colloids could also be influenced by this preferential adsorption (see p. 55).

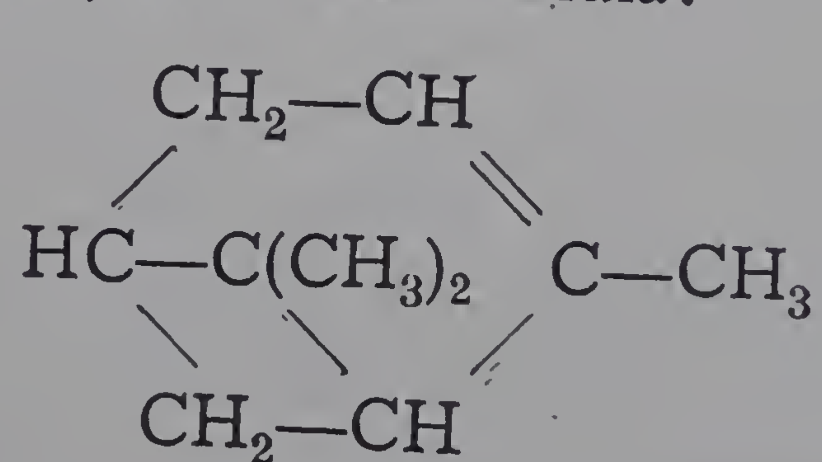
We have discussed only one of the main components which could explain the activity of metals. A second group of important reducing agents are the terpenes. We have mentioned the possibility of adsorption of organic compounds by metals. As this problem is closely related to the problem of emanation of volatile matter by organic bodies they are linked together.

Cause of emanation of volatile matter by organic bodies

We have seen that all organic compounds and also living matter are able to extrude volatile components which act as reducing agents. Although one of the these components could be hydrogen, the most important probably belong to the group of terpenes. We mentioned on p. 36 the influence of essential oils and resins on photographic plates, the influence of light on the activity of resins and related compounds and the lack of influence of light on other chemical compounds (see p. 41). A very abundant liquid in Conifers is *Turpentine* which consists of a solution of various resins (e.g., Colophony) in oil of turpentine.

This oil is a colourless liquid with a rather pungent odour, which is probably caused by small quantities of substances formed by oxidation. On exposure to air it becomes more viscous and gradually converts into resinous oxidation products which are inactive on a photographic plate.

The principal component of oil of turpentine is *pinene* ($C_{10}H_{16}$) a so-called dicyclic terpene, with the formula:



The dicyclic terpenes often go through remarkable changes, one of the rings undergoing fission, giving products which sometimes pass again into bridget ring structures of a different kind. With moist hydrogen chloride *dipentene dihydrochloride* is formed. With sulphuric acid in alcoholic solution it gives *terpineol*. When heated with organic acids it yields esters of *borneol* and *iso borneol* ($C_{10}H_{17}OH$), derivates of camphor. All these transformations are possible because HCl, H_2SO_4, etc., occur in traces in the atmosphere and in the organic tissues. Pinene readily undergoes oxidation, yielding various compounds such as *p.toluic*, *terephthalic*, *terpenylic* and *terebic acids*. In moist air and sunlight it gives *sobrerol* or *pinol hydrate* $C_{10}H_{16}(OH)_2$, which with dilute mineral acids is converted into *pinol* ($C_{10}H_{16}O$).

The property of being easily oxidized makes pinene a strong reducing agent and able to influence a photographic plate.

This one example demonstrates how extremely complicated is the smallest problem in nature when we try to get down to the roots of the problem.

The previous pages have shown that practically all living and non-living matter emanate volatile inorganic or organic compounds; in other words *every object in nature is surrounded by a kind of aura composed of volatile compounds*, which are able to interact, particularly due to the colloidal structure of the proteins of living matter. Because of the great diffusion speed of these volatile compounds and their rather rectilinear diffusion this emanation behaves rather as a kind of radiation. The great sensitivity of the colloidal matter of the living cell for these volatile diffusion rays and the importance for all living processes is evident after the previous discussions and the reader probably realizes why this subject was treated at length; it is a powerful approach to one of the aspects of the most complicated problems of divining, i.e., radiesthesia. The STEMPELL effect is another example of the sensitivity of colloidal substances to volatile matter[1].

IB. 1. b: The experiments of STEMPELL *with* LIESEGANG *rings* (see p. 27 and Bibl. No. 137-155)

About 1898 (Bibl. No. 144) LIESEGANG discovered the phenomenon of "rhythmic precipitation" in colloidal substances (see fig. 5); a typical example in nature is the beautiful coloured rings in agate. The mathematical treatment of this subject is rather complicated, but the following summary explains the mathematical train of thought.

If two liquids, with different concentration and speed of diffusion, diffuse through a colloidal substance such as gelatin, in two opposite directions, and if at a certain concentration of ions one of the liquids is able to precipitate the other at a certain point A in the beginning of this diffusion process, this critical concentration could be reached and one of the liquids precipitate; e.g., NH_3 and $MgCl_2$; NH_3 diffuses more rapidly and at a certain point MgOH is precipitated. The NH_3 continues its diffusion, but in the immediate neighbourhood of the point A, due to the previous precipitation, the Mg concentration has decreased to such an extent that only at a certain distance does the critical concentration occur which enables a new reaction with NH_3 and a second precipitation to take place. This rhythmic precipitation process by unequal diffusion is generally only possible in viscid media such

[1] After completion of the manuscript two other publications were found which confirm the experiments of RUSSELL.
1. A publication by J. C. MABY in 1937 (see Bibl. No. 147a), is discussed on p. 331.
2. A publication by G. LE BON in 1908 (see Bibl. No. 143a) deals with the activity of various metals, especially zinc, aluminium and platinum on photographic plates.

(Continued on p. 49)

as jellified substances which accentuate these differences in diffusion speed. However, FRICKE also succeeded in producing rhythmic precipitations in ordinary aqueous solutions by using glass capillaries with a diameter of 2 mm.

The further away from the initial point of diffusion and the smaller the speed of diffusion, the longer it will take before the critical point of diffusion is reached. In other words *the distances between the rings, in case of concentric diffusion, increase outward from the centre of a jelly.*

The details of this process were studied by FRICKE who, immediately after precipitation at a certain point cut up the gelatin with a microtome and analyzed the sections chemically. The results were confirmed by this mathematical calculation (see Bibl. No. 139 and 140).

It is evident that apart from the moisture content of the atmosphere and the initial concentration of the diffusing substances, external physico-chemical forces can influence considerably the shape and density of the LIESEGANG figures by changing the viscosity of the jelly (e.g., by changes in thickness, temperature, electric charges, etc.) and the speed of diffusion (e.g., by chemical action of oxidizing or reducing agents; magneto-chemical effects, see page 83; irradiation; electro-static fields; etc.).

The great sensitivity of the LIESEGANG figures led STEMPELL to use this phenomenon in order to prove the existence of mitogenetic radiation. Between 1929 and 1931 he made a great number of experiments in his laboratory in Münster. ROMBERG in Buldern (see Bibl. No. 152-155) independently did the same.

STEMPELL used in his experiments a thin chrom-gelatin layer which was poured on a glass plate 8½ × 10 cm. The chrom-gelatin was prepared by dissolving 12 g of gelatin in 160 ml warm water; 0.4 g of ammonium chromate was then added snd the mixture filtered through glass-wool. 1 or 2 drops of a 20% solution of ailver nitrate were placed in the centre of the chrom-gelatin. The drops first showed as a globe on the gelatin, but gradually they sank in the gelatin and reddish brown concentric rings of silver-chromate were formed at regular intervals (see fig. 5), the distances increasing towards the periphery. STEMPELL distinguished three kinds of LIESEGANG-rings:

1. secondary rings: thick, well-marked, dark blue, brown, red or black concentric rings easily distinguishable to the naked eye;
2. primary rings: fine, dark grey rings, only observable with a magnifying glass, in general parallel to the secondary rings but sometimes cutting those rings at an angle;
3. shadow-rings: shadow spots occurring between the secondary rings at places where they bulge outwards and where the secondary ring should have been developed.

Immediately after the drops of $AgNO_3$ were placed on the gelatin it was air-tight covered by a glass plate with a slit in it; above the plate was placed a sheet of cellophane. Before the drops had sunk in and the

Continuation of note on p. 48:

He also found that a few hours exposure to direct sunlight of such metals, which were placed afterwards in contact with a photographic film, gave rise to fogging. After a few days the metals were no longer able to give an image. A clean silver coin, placed in a full summer's sun for some while and then quickly transferred on to a photographic plate in a dark room, recorded its engraving on the plate.

formation of rings had started a mash of onion roots or other living matter was placed on the cellophane. The whole apparatus (see fig. 4) was placed in a humid room at a constant temperature of 20-22° C. The mash was renewed 5 to 7 times per hour, though later experiments by SIEBERT showed this to be unnecessary. Below the slit in the glass plate and below the cellophane (see Fig. 4), a disturbance in the formation of rings could be seen (see Fig. 5) and the red brown colour changed to dark yellow.

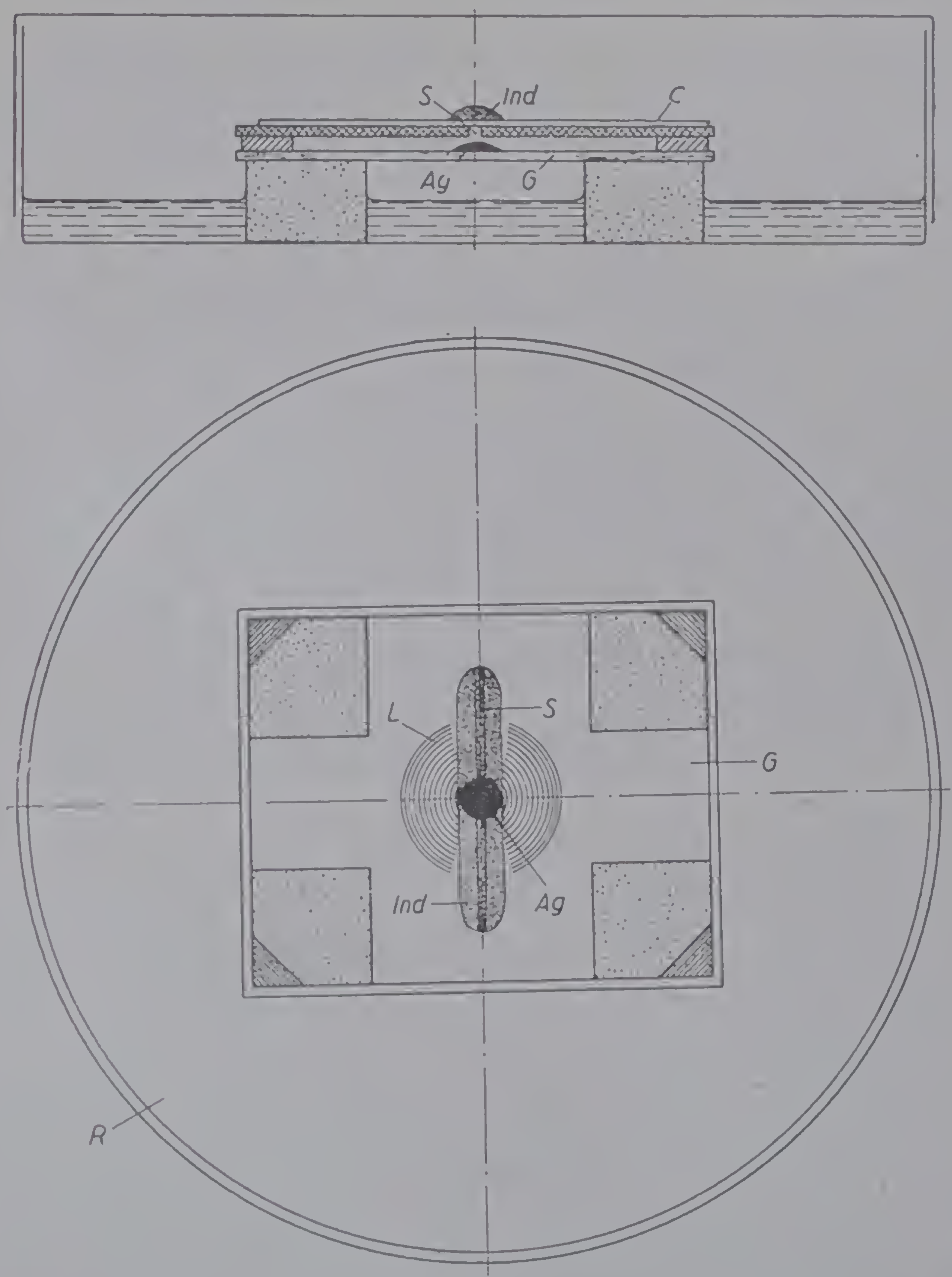


Fig. 4: (Bibl. No. 155) S. = slit in glass plate, abt. 1 mm wide and 6 cm long; Ind. = inductor; C = cellophane; Ag = 1 or 2 drops of a 20% solution of $AgNO_3$; G = glass plate $8\frac{1}{2} \times 10$ cm covered with chrom-gelatin; L = LIESEGANG rings; R = humid room.

The experiments of STEMPELL have shown that all kinds of living matter prevent the formation of rings below the slit if the following precautions are taken:

1. the gelatin must have the right composition, i.e., the rings should not be too thick nor too thin and the distances in between should not be too small; this could be arranged by adding some pyrogallol, which has a checking influence on the formation of rings;
2. the temperature must be sufficiently high (abt. 20-22° C) and kept constant;
3. the amount of light in the room must be sufficient and more or less constant.

The STEMPELL effect was obtained with and without an intermediate layer of cellophane.

STEMPELL's experiments were repeated by VAN ITERSON, together with HOMAN VAN DER HEIDE, and by SIEBERT.

VAN ITERSON (see Bibl. No. 142) made some experiments in the laboratory of technical botany in Delft, Holland, in the month of September, which has been considered a favourable month for mitogenetic processes

by GURWITSCH and others. The mash of onion root on the cellophane was renewed every 5 to 6 hours. VAN ITERSON obtained the same disturbances as STEMPELL, but he was convinced that they were due, not to mitogenetic radiation but to volatile components extruded by the mash. The following reasons were responsible for his conclusions:

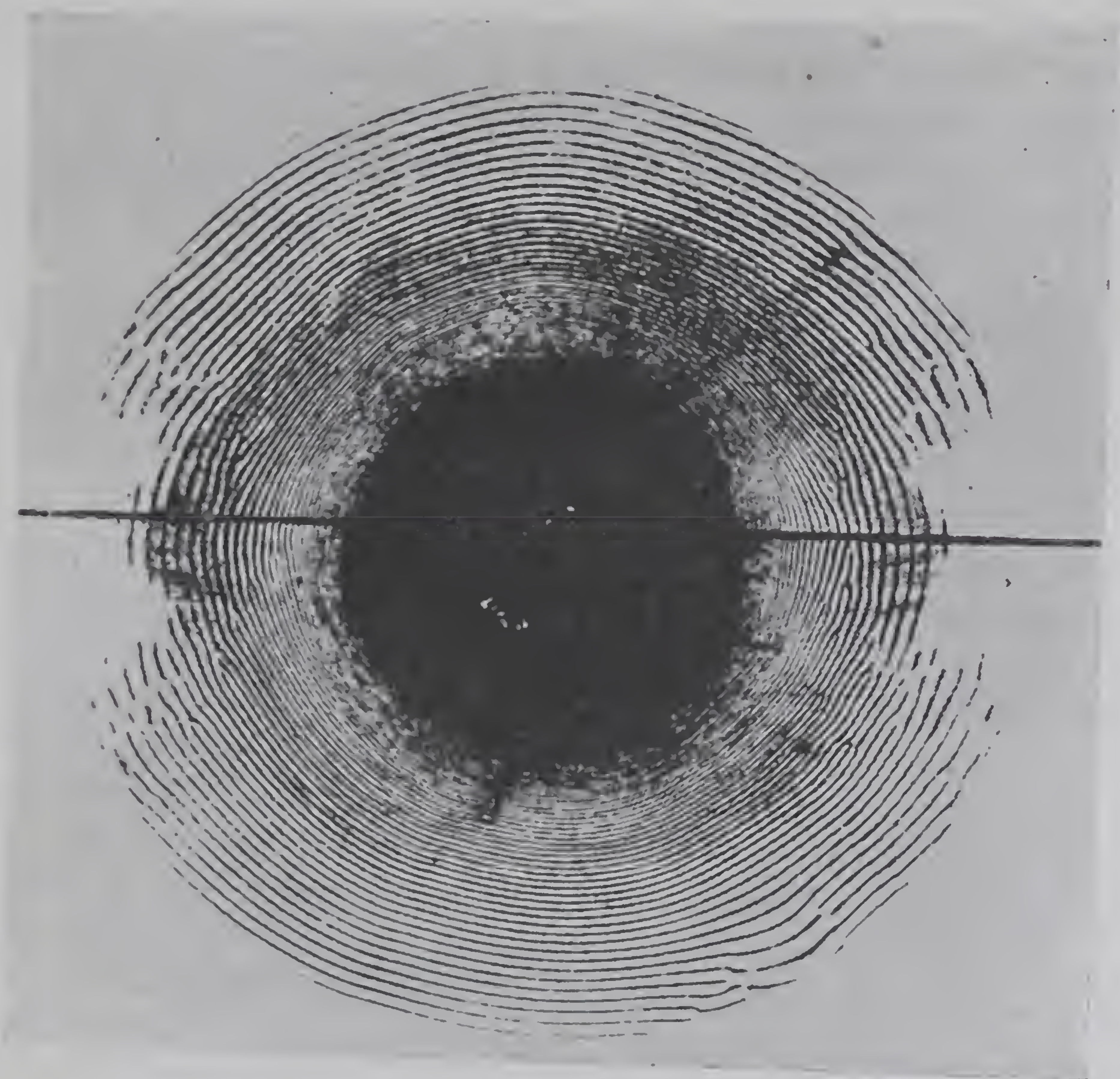


Fig. 5: (Bibl. No. 155) Disturbance of LIESEGANG-rings after 21 hours, caused by a mash of onion roots.

1. the basal part of the cellophane plate often had a pronounced onion smell after the experiment;
2. if the gelatin was separated from the mash by glass, which was air-tight attached to the box, no reactions were obtained;
3. similar experiments with a 0.5 mm thick quartz plate or 0.25 mm thick uviolglass prevented or considerably weakened the STEMPELL effect. The disturbances in the latter case were not only restricted to the area below the slit, but occurred also in other places and even much stronger.

VAN ITERSON and HOMAN VAN DER HEIDE therefore believe that differences in moisture, temperature, etc., are the only causes of the disturbances below quartz plates.

SIEBERT (see Bibl. No. 151) made 170 STEMPELL experiments and confirmed the STEMPELL effect, but he denies that this indicates a

GURWITSCH radiation. We mentioned SIEBERTS experiments with muscles on p. 20. SIEBERT was convinced that mitogenetic radiation as such existed, but that the following experiments indicated the action of volatile components.

1. The disturbances occurred not only below the slit but also further away.
2. Tissue of cancer tumour and electrically stimulated muscles, which showed the mitogenetic radiation very clearly with the GURWITSCH method, were inactive.
3. Parts of the onion which do not show any GURWITSCH radiation with the ordinary GURWITSCH method are still active during the STEMPELL experiments.
4. Air-tight attached quartz plates prevented the STEMPELL effect.
5. In a solution of ammonium bichromate the chromate ions were slowly precipitated with $AgNO_3$. When an air-current was conducted through this suspension of silver chromate, which first passed a mash of onion roots, the colour of the red brown suspension changed to yellow within an hour. This occurred only in dilute suspensions and would explain the fact that only near the periphery of the gelatin, below the split, do the strongest yellow discoloration and disturbances occur. According to SIEBERT, TOKIN (1930) and OZAJA (1930) the active substance of onions is *allyl sulphide* $(CH_2 = CH — CH_2)_2S$, an unpleasant smelling liquid boiling at 140° C and occurring in many Cruciferae.
6. Other substances create similar disturbances, e.g., garlic, tinctura asae foetidae, formaldehyde, acetaldehyde. Ammonia disturbs all the rings within an hour. Armoracia rusticana and mustard powder prevent the formation of the primary rings, only one ring being formed round the centre. The active component of garlic is probably *allyl disulphide* $(C_3H_5)_2S_2$, of mustard seeds *allyl isothiocyanate* $(CH_2 = CH — CH_2 — N = CS)$, which produces blisters when placed on the skin.

After these publications a great number of new experiments were made by STEMPELL. During the International Cytological Congress in Amsterdam, in 1930, Dr T. REITER confirmed STEMPELL's observation that influence on the LIESEGANG rings could be seen even through air-tight-attached quartz plates. Although STEMPELL fully realizes the influence of volatile components, he is convinced that a radiation phenomenon also occurs. STEMPELL does not mention RUSSELL's publications in his extensive bibliography, which suggests that he did not know about these experiments. We have seen on p. 39 that gelatine, colloidon, gutta-percha tissue, paper, etc., are transparent for volatile matter. It is very likely that cellophane too is transparent (see exp. 1 of VAN ITERSON, p. 51). The uviol glass and quartz plates were so-called air-tight-attached to the box with Canada balsam. It is doubtful, however, whether Canada balsam is completely air-tight. Thin sections of rocks made with Canada

balsam often show microscopically small fissures as a result of contraction after cooling. Although STEMPELL pointed out that short-wave ultraviolet rays are absorbed by quartz and uviol glass, which could explain the lack or weakness of action with these media, it must be remembered after the discussion of the RUSSELL effect that very few substances are really tight to volatile matter.

The main results of the latest STEMPELL experiments can be summarized as follows:

1. All plant and animal cells create the STEMPELL effect (according to STEMPELL a combination of a gas emanation and a radiation);
2. Oxidizing processes (e.g., presence of H_2O_2) check the formation of secondary rings; reductional processes increase it;
3. Intensive gas emanation checks the formation of rings; slight emanation of gases, however, increases this process, e.g., pyrogallol increases the formation of rings if traces only are used, greater quantities check it. A drop of onion extract, placed immediately next to the gelatin, prevents the formation of secondary rings and yellow discolorations occur. Further away, between the non-disturbed rings and the zone of disturbance, a thin zone occurs with increased formation of rings.
4. Intensive irradiation (daylight) of the mash increases the formation of rings; darkness decreases the process.
5. If monochromatic light is used, the very small and very large wave-lengths are for the greater part inactive. The greatest influence is obtained by using an average wave-length, particularly ultra-violet. Infrared or X-rays are inactive.
6. The thin primary rings often behave contrary to the thick secondary rings with reference to exp. 3 and 4.

We mentioned on page 22 that the opposite action of intensive gas emanation and irradiation could prevent the STEMPELL effect; this might explain the difficulty of proving the existence of the GURWITSCH radiation.

IB. 2: Sensitivity of colloidal substances to electric fields (see table on p. 27, Bibl. No. 156-165)

IB. 2. a: Electrophoresis (see Bibl. No. 163)

It is well known that colloidal particles possess an electric charge which creates a movement of those particles in an electric field. Depending on this movement towards the positive or negative pole, the colloidal suspensions are divided in anionic and cationic suspensions (or emulsions), the particles in the first case being negatively charged, in the second case positively. According to THORNTON practically all colloidal suspensions created by vegetable matter, such as diatoms, unicellular algae and other vegetable micro-organisms, are cationic; in other words these particles have a positive charge. However, animal

micro-organisms (and the animal cell), and also the amoeba and bacteria are negatively charged (see also p. 200, electric field of plants).

This movement of electrically charged particles in an electric field is called *electro-* or *cataphoresis*.

The speed of movement depends on different factors:
1. the potential differences between the electrodes;
2. the viscosity of the liquid;
3. the acidity of the liquid.

The direction of movement is determined by:
1. the electric charge of the particle and the position of the electrode;
2. the resistance of the surrounding fluid.

SEIFRITZ, SCHEMINZKY, a.o. have shown that cells and their inclusions possess sufficiently large electric potentials to bring about a migration in an electric field. Spermatozoids and other animal cells migrate towards an anode. SEIFRITZ could demonstrate also that if micro-electrodes of platinum are inserted into the plasmodium of a slime mold — Physarum polycephalum — the proto-plasmatic particles line up in perfect parallelism at an electric tension of 5 Volt (distance of the electrodes being 1.5 mm).

IB. 2. b: Agglutination experiments of DE KRUIF *and* NORTHROP (see Bibl. No. 161-162)

The electric charges of colloids determine their sensibility to agglutination. Agglutination of colloids, in other words destruction of the typical physico-chemical properties of this system, is generally created under the following conditions:

1. *Addition of electrolytes*: the effect depends on different factors:
   a. charge of the ions of the electrolyte and the colloidal particles;
   b. valency of the ions (in general higher valency has greater effect).
   If too great an ionic charge is added the colloid does not agglutinate, but an opposite charge is obtained, determined by the excessive electrolyte. Many colloidal suspensions are surrounded by a protective layer which prevents the agglutination effect of electrolytes, either because the ions of the electrolyte are unable to contact the charged colloidal particle, or because the protective emulsion has a checking effect on the coagulation movements.

2. *Irradiation:* α-rays could have an influence on negative colloids, but the effect is small, due to the slight penetration capacity; γ-rays and ultraviolet rays have no effect; β rays which can penetrate a few cm are able to precipitate positively charged colloids. Further details are discussed on p. 64 sub I C 1 b.

3. *High temperatures.*

4. *Electric potential differences.*
   a. DE KRUIF and NORTHROP discovered that whenever the potential difference between the surface of a colloidal particle (and also of bacteria) and the solution is less than 15 mV, they agglutinate, provided the cohesive force (i.e., the surface tension) is not affected[1]. In the case of bacteria treated with an immunity serum the cohesive force remains constant and the agglutination potential can be determined by measuring the migration speed in an electric field, just before the agglutination occurs; the potential difference can be calculated with the formula of HELMHOLTZ.
   F. POWIS could prove that oil emulsions become unstable if the potential gradient falls below 30 mV.
   b. If the cohesive force is decreased this critical potential also decreases. If the cohesive force is very small no agglutination occurs even though the potential is reduced to zero.
   c. All electrolytes treated in concentrations less than 0.01 - 0.1 Normal, affect primarily the potential, while in concentrations larger than 0.1 N the decreasing effect is principally on the cohesive force; below 0.001 N agglutination depends solely on the potential.

By studying the results of DE KRUIF and NORTHROP it becomes evident that *the coagulating efficiency of a salt depends on the effect it has both on the potential and cohesion.*

Thorium chloride added to a suspension of bacillus typhosus in concentrations $< 5 \cdot 10^{-6}$N does not create agglutination because the potential difference remains $>$ 15 mV. At concentrations $5 \cdot 10^{-6} — 5 \cdot 10^{-5}$ the potential difference between particles and solution will fall below 15 mV and agglutination occurs. At concentrations $5 \cdot 10^{-5} — 5 \cdot 10^{-1}$ the pot. difference is $>$ 15 mV and agglutination cannot take place. At higher concentrations, at a certain moment, agglutination is possible again, whereas still higher concentrations can prevent this.

In the following chapters we discuss several external processes that can alter the natural distribution of potential differences in the body. The previous discussions have shown that slight changes create favourable or unfavourable conditions for bacteria and other micro-organisms.

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[1] The *potential difference* between a colloidal particle and the surrounding solution was calculated by NORTHROP (Bibl. No. 161) by measuring the migration speed between two electrodes. According to the HELMHOLTZ-LAMB equation the pot. difference

$$pd = \frac{4\,n\,v\,\pi}{Kx}$$

if n = viscosity of the solution; v = velocity of particle in cm/sec; K = dielectric constant of the sol.; x = pot. gradient in fluid, i.e. drop in pot. in E.S.U. per cm.

The *cohesive force* was determined by covering a thick glass slide with a thin film of a very heavy suspension of washed organisms (bacillus typhosus) and the film then dried. A heavy cover slip was similarly prepared. The glass slide was immersed in the solution to be studied and the cover slip placed on top of it, but connected to a fine platinum wire by a "DU NOÜY-surface tension apparatus" (see *J. of gen. Physiol.*, 1918, p. 521). The force required to separate both slides was registered. The cohesive force markedly decreased in concentrations larger than 0.01 N. This figure is not affected by the valency or electric effects of the ions.

On p. 18, referring to the mono-molecular layers, we indicated another factor important for the penetration of micro-organisms. It is evident that one of the causes of the influence of external electro-magnetic fields on our health can be found in the influence on pathogeneous micro-organisms. Although we shall treat this problem at greater length in the last chapter on dowsing, it is advisable to add a few words here on the living conditions of bacteria.

Bacteria are one of the most resistant groups of micro-organisms and it is extremely difficult to destroy them. The most characteristic properties are:

1. They are bound to certain *limits of temperature.* So-called *psychrophilic bacteria* have an optimum temperature of 5-10°C, *mesophilic bacteria* 30-37°C, *thermophilic bacteria* 55-60°C etc.
2. They are very sensitive to *oxidizing or reducing agents.*
3. They behave as *negatively charged suspensoids* and are therefore subject to *electro-phoresis*, *adsorption by oppositely charged membranes* (principle of filtering of water in sand filters) and *agglutination* (DE KRUIF-NORTHROP effect).
4. They are bound to a certain *degree of acidity* of the solution; most bacteria grow quickest in neutral solutions.
5. They require a certain *osmotic pressure*; if the internal pressure is too low (i.e., very dilute solutions) liquids enter the cell-interior, so-called *plasmoptysis*; if the pressure is too high (highly concentrated salt solution) liquids leave the cell, so-called *plasmolysis.*
6. They are very sensitive to *electro-magnetic waves* of certain wavelength; ultraviolet rays between 2,800 and 2,500 Å, and high-frequency Hertzian waves (see p. 65).

In order to destroy bacteria, at least three artificial methods are used:

1. *Chemotherapy*, i.e., application of chemical poisons, so-called *disinfection.*
2. *Physicotherapy* or the method of *sterilization.* This could be achieved:
   a. by drying (see property 5);
   b. by application of electro-magnetic waves (see property 6);
   c. by boiling solutions (see property 1);
   d. by application of disinfectants based partly on chemical, partly on physical principles; the important disinfectants are acids, alkaline liquids, coagulating agents, antiseptic soaps, etc., the action of the latter being based on the decrease in surface tension, thus enabling the adsorption of the bacteria.
3. *Biotherapy*, i.e., destruction of bacteria with bacteriophagus.

These different processes take place also in the human and animal body and, as external electro-magnetic fields can influence each of these processes, they are of importance for the discussions in chapter III.

Bacteria disappear during a destructive process according to a specific rule. According to MADSEN, CHICK, a.o., there is always *a constant ratio between the number of bacteria present and those which disappear;* e.g., if the initial number is 1,000,000 and 900,000 die in a certain time-interval, then during the following time-interval 90,000 disappear from the 100,000 remaining bacteria. *The death curve is characteristic of monomolecular reactions*, i.e., a reaction in which the rate of action is deter-

mined by the concentrations of only one of the groups of reacting molecules. A logarithmic curve of the number of remaining bacteria (or molecule) and the time-interval gives a straight line.

According to CHICK the death curve of bacteria resembles the curve of coagulating proteins. He assumes that only one particular group of protein molecules is destroyed during these processes of destruction of bacteria.

IB. 3. c: Sensitivity of colloidal substances to magnetic directive forces (see table on p. 27 and Bibl. No. 166-169)

In order to measure the elasticity of colloidal liquids with great viscosity FREUNDLICH and GRIESMEYER (Bibl. No 166) placed magnetic globes in those liquids. By changing the intensity the globes move in a magnetic field and cause internal disturbances in the colloidal structures. The rate of movement could be used as a basis for the measurement of the elasticity because by switching an electro-magnet on and off the globes would jump back to their original position. However, in a continuous field, after a long period, permanent deformations are created.

FREUNDLICH used fine metal particles of 18 μ diameter. He found that protein colloids had a particularly high limit of elasticity.

We mentioned on p. 13 the structure of the plastides in plants. According to J. MOORE (Bibl. No. 169) not only the cell-nucleus but also the chloroplasts are rich in iron-components which are important for the photo-synthesis of plants (O. WARBURG 1925, K. NOACK 1927, O. WEHNER 1928). The iron components are bound to protein molecules, but can also move freely as iron ions in the electric fields of the cell. According to GRIESMEYER (Bibl. No. 167) chemical compounds, such as SO_2, potassium cyanide, etc., act as poison on these catalytic acting iron ions and prevent the photo-synthesis; iron-containing food increases the catalytic function. Magnetic fields can influence the distribution of the iron ions in the grana (see also p. 81, influence on ions) which in turn influence the living processes in general.

On p. 268 we discuss the experiments of MRS LENGYELL (Bibl. No. 168) who demonstrated the permanent changes of tissue structures in strong magnetic fields.

IB. 6. b: Sensitivity of colloidal substances to the chemical action of metals (see table on p. 27 and Bibl. No. 170-175)

We observed, during the discussion of the RUSSELL effect (see p. 36), and the influence of cations on agglutination (see p. 55), the great influence of traces of metals on colloidal substances in general and living matter in particular. We have just mentioned the importance of iron but a more systematic review of the importance of metals to living processes is worth while.

The main supply of metals required for living organisms is obtained from the soil through the roots of plants. The minerals in the soil are weathered and with the organic acids of the plants the useful elements are absorbed and used for the development of the plant, which in a later stage is consumed by animal or man.

In handbooks on agriculture (see Bibl. No. 170-175) the significance and occurrence of the elements is described in detail. A few examples are given only to demonstrate the influence of soil on the development of organic life.

Green plants generally require ten elements: *carbon* (C), *potassium* (K), *calcium* (Ca), *magnesium* (Mg), *iron* (Fe), *hydrogen* (H), *oxygen* (O), *sulphur* (S), *phosphorus* (P), and *nitrogen* (N). However, recent studies (see Bibl. No. 172 and 175) revealed that rarer metals in soil such as Mn, Cu, Zn, Ba, Sr, Cs, Ti, Cr, V, Al, etc., are also very essential. Mc HARGUE could prove that in Kentucky grass Cu, Zn, Ni and Co in particular help plants to synthesize organic compounds which function as catalysts, enzymes and vitamins; these in turn, upon entering the animal system as food, are resynthesized into hormones, etc., which are essential to growth and functioning of the organisms. ALLISON could prove that copper salts enormously stimulated the growth of plants in the peat lands of Everglades.

Titanium, molybdenum and thallium have also been found in plant cells and seem essential for the physico-chemical processes in the cell.

Lack of *iron* prevents plants from growing a green colour (*chlorosis*); lack of calcium creates poisoning; *magnesium* is required for the building up of the chlorophyll molecule; iron is also required for the building up of chlorophyll molecules (although it does not occur in these molecules) in colloidal protoplasm; *potassium* and *calcium* often act as regulators; *manganese* is sometimes required for oxidizing processes in plants (ash of tea leaves contains 4.5% MnO).

The absorption of the elements depends on the *permeability* of the plant-cells, which is influenced by the electric conditions of the cell-membranes (see p. 17), temperature, the light factor, the water-content of the protoplasm, etc. The great number of elements required by organisms makes it logical that sea-food is very important as it contains at least 34 of the chemical elements.

The main sources of supply on land of the above-mentioned metals are:

for *potassium:* the minerals felspar (particularly orthoclase: $KAlSi_3O_8$), leucite ($KAl\,Si_2\,O_6$), muscovite ($H_2\,KAl_3\,Si_3\,O_{12}$), biotite (see below), glauconite (FeAl silicate with 2-15% K_2O), volcanic glass, etc.;

for *calcium:* limestone, limy soils, certain felspars ($CaAl_2Si_2O_8$), several fertilizers (such as superphosphate, etc.,) contain calcium ions;

for *magnesium:* certain clay minerals, biotite $\{(KH)_2\,(Mg, Fe)_2\,(AlFe)_2\,Si_3O_{12}\}$;

for *iron:* biotite and many other minerals;

for *copper:* minerals of copper sulphides, etc.;

for *manganese:* manganite ($Mn_2O_3 \,.\, H_2O$), hausmannite (Mn_3O_4), etc.

The average composition of the three spheres of animal life, the *lithosphere* (earth crust)

the *hydrosphere* (seas, lakes and rivers) and the *atmosphere*, was calculated by F. W. CLARKE (in 1889) and J. H. VOGT (in 1898) as follows:

Element	Lithosphere	Hydrosphere	Atmosphere
1. Oxygen (O)	47.2%	85.79%	23.01%
2. Silicon (Si)	28	—	—
3. Aluminium (Al)	8	—	—
4. Iron (Fe)	4.5	—	—
5. Calcium (Ca)	3.5	0.05	—
6. Sodium (Na)	2.5	1.14	—
7. Magnesium (Mg)	2.5	0.14	—
8. Potassium (K)	2.5	0.04	—
9. Hydrogen (H)	0.17	10.67	—
10. Titanium (Ti)	0.33	—	—
11. Carbon (C)	0.22	0.002	0.01
12. Chlorine (Cl)	0.025—0.04	2.07	—
13. Phosphorus (P)	0.09	—	—
14. Manganese (Mn)	0.075	—	—
15. Sulphur (S)	0.06	0.09	—
16. Barium (Ba)	0.03	—	—
17. Fluorine (F)	0.025—0.004	0.00008	—
18. Nitrogen (N)	—	—	75.68
19. Zirconium (Cr)	0.01—0.02	—	—
20. Chromium (Cr)	0.01	—	—

Nickel, strontium, lithium, bromine and boron together are abt. 0.01-0.001%; cobalt, argon, iodine, rubidium, tin, cerium, yttrium, lanthanum and arsenic, 0.001-0.0001%.

So far we have discussed only the influence of deficiencies of certain metals on plant life. A few words must be said on the significance of metals to animal life (and man).

Sodium and *potassium:* occur as chlorides, phosphates, carbonates and in combination with simple organic acids in large molecules of proteins and other complex compounds. Potassium occurs mainly in the cells. Sodium chloride is found chiefly in the body-fluids and is responsible for maintaining the correct osmotic pressure of those fluids. It is excreted mainly in the urine. About 2 grams a day are required in order to maintain its store.

Calcium: occurs in human blood abt. 10 mg per 100 ml. The calcium metabolism is controlled by the parathyroid glands. It is required also for the bones and teeth. It was found in the U.S.A. that only where calcium and phosphate are plentiful can forage crops be grown of such composition that they reproduce strong, healthy, well-boned animals. Phosphorus is needed in large quantities in the bones and as "buffer" substances in blood (see also p. 158, muscular activity). Abt 0.88 g. of phosphorus is required per day for a man of average weight.

Iron: occurs in hemoglobin of vertebrates and in certain tissue pigments. Abt. 15 mg a day is required. The natural sources for iron are liver, kidney, eggs, fish, spinach, etc. It was observed in the U.S.A.

(Florida) that low iron content in soils causes anemia among rura children, as they live only on home-grown food.

copper: required for the hemocyanin of invertebrates.

zinc: found in large concentrations in the pancreas. The exact function is not known.

magnesium: the exact function in animal life is so far unknown (the importance to plant life has been mentioned above). It seems that a quantity of 0.22 g/day is adequate.

manganese: essential for certain animals, rats for example (female rats loose interest in their young by lack of Mn).

Amongst the non-metallic elements three are of particular importance: iodine, phosphorus and fluorine.

The influence of *phosporus* is mentioned above.

Iodine is present in minute traces in all our tissues. However, in the thyroid gland it occurs in large quantities, forming an integral part of thyroxin (abt. 65 %), a hormone substance ($C_{15}H_{11}O_4NI_4$). If individuals receive insufficient amounts of iodine through drinking water or plants (e.g., when living in areas with lack of marine deposits)goitre might develop.

The influence of *fluorine* on our health is indicated best by the discovery that the inhabitants of Deaf Smith County in Texas have only half the number of cases of tooth decay (caries) than in areas hitherto reported as lowest in the U.S.A. (see Bibl. No. 171). The soil is composed of an upper layer of dark sandy clay, overlying very calcareous marl. The effect of this soil on the vegetation and food is shown by the following:

1. local bread has an abnormally high protein content;
2. this bread contains 6 times the average amount of phosphorus;
3. the milk contains a third more phosphorus than normal milk;
4. the water has a small amount of fluorine (one part per million parts of water).

Too much fluorine (i.e., more than 2.5 mg/liter) in water causes mottling and disfigurement of the teeth; a small amount, however, protects teeth from cavities and decay.

In S. Dakota (U.S.A.) it was found that traces of the rare element *selenium* in the soils creates a very unhealthy food.

These few data indicate sufficiently the great influence of traces of elements in general and of metals in particular on the development of living matter. This is due to the colloidal protein structure of the cell and the sensitivity of those structures to the physico-chemical action of those metals.

IC. 1. a: Sensitivity of solutions to electric fields
(see table p. 27 and Bibl. No. 176-181)

Apart from the phenomenon of *electrolysis*, which creates movements of cations and anions and causes changes in the concentration of ions, the phenomenon of *electro-osmosis* also occurs if the potential differences are considerable. It is not the particles or ions in the solution that move separately in this case, but the solution as a whole which moves towards or away from the electrodes. If the E.M. force in tissue, i.e., near membranes (see p. 17) rises high enough it might give rise to circulating currents, which

in turn are capable of driving fluids through membranes by differences in concentration of electrolytes. Electro-osmosis also plays an important role in the rise of sap in plants. It has been found by POPESCU (Bibl. No. 179) a.o. that a definite zone of the roots of plants is responsible for the intake of fluid from the soil. This active zone is situated where the root exhibits the greatest longitudinal growth, the so-called *stretching-zone*. It is this zone which, according to LUND and KENYON (Bibl. No. 178), is characterized by an outstanding E.M.F., distinctly different from other parts of the root. Movements of body-fluids in animals through capillaries etc. might often not be due to cohesive forces as is generally assumed, but to electro-osmosis.

SSAWOSTIN (Bibl. No. 180) could prove that during magnetic experiments (p. 267), rotational movement in the plasma of vegetable cells (see p. 13) are caused by small electric currents of abt. 10^{-5} ampère or less.

Experiments of GAMGEE (see Bibl. No. 232) on the *electrolysis* of solutions of pure oxyhemoglobin (see p. 78) are very instructive. He discovered the following:

1. when the solutions are subjected to an electric current of 3-5 milliampère at 15°C, a rapid subsidence of the colouring matter takes place, the upper layers of the solutions becoming colourless. After stirring it becomes instantaneously soluble again. The same happens with carbonic oxide hemoglobin (see p. 78).
2. On continuing the passage of current, secondary reactions occur and gas is developed.
3. With greater strength of current and after long application red colouring matter is sometimes deposited near the anode.

It is evident that all external and internal physico-chemical processes which are able to create internal potential changes in the living body, even on a considerably smaller scale, might influence the structure and composition of the blood with all its consequences.

IC. 1. b: Sensitivity of solutions and colloids to electro-magnetic waves and radio-active radiation (see table p. 27, Bibl. No. 181a-213)

The influence of electro-magnetic waves and radioactive radiation on living matter represents one of the most important, complicated problems of biophysics. A thorough understanding of the basic processes is most essential for the understanding of divining phenomena. An excellent review can be found in Bibl. No. 199 and 207.

The radiation to which living matter is exposed on earth can be divided into two groups: electro-magnetic waves sensu stricto and corpuscular radiations.

Electro-magnetic waves can be subdivided according to their wave-length (λ) as follows ($1\mu = 0.001$ mm, $1\ m\mu = 10^{-7}$ cm, 1 A.U. $= 10^{-8}$ cm):

γ-rays: $\lambda = 0.003\text{-}0.01$ mμ (radioactive radiation which can penetrate in air 80-100 m before the ionisation capacity is reduced to half its original value)
X-rays: $\lambda = 0.01 - 1.0$ mμ; therapeutic rays: $\lambda = 0.05 - 0.02$ mμ
diagnostic rays: $\lambda = 0.1 - 0.05$ mμ
ultraviolet: $\lambda = 1.0 - 390$ mμ (in artificial light 180 mμ.
violet: $\lambda =$ abt. 390-450 mμ
vibration number n $= 77 \times 10^{13}$)
blue: $\lambda = 450\text{-}490$ mμ
green: $\lambda = 490\text{-}550$ mμ
yellow: $\lambda = 550\text{-}590$ mμ
orange: $\lambda = 590\text{-}630$ mμ
red: $\lambda = 630\text{-}770$ mμ (n $= 40 \cdot 10^{13}$)
(violet to red: visible light)
infrared: $\lambda = 770$ mμ - 220 μ (heat-radiation)

high frequency Hertzian waves:

magnetron-radar waves: $\lambda =$ few mm - 3 cm
high-frequency Hertzian waves: $\lambda = 30$ cm - 3m (n $= 10^8 - 10^9$ Hz)
ultra-short waves: $\lambda = < 10$ m
short-wave therapeutic waves: $\lambda = 3 - 30$ m (n $= 10^7 - 10^8$ Hz)
short waves: $\lambda = 10 - 100$ m
diathermic waves: $\lambda = 300 - 500$ m (n $= < 10^6$ Hz)
ordinary radio waves: $\lambda =$ several hundred m to km
Decca-radio waves: $\lambda =$ up to 20 km

Corpuscular radiation can be divided as follows:

1. *Radioactive radiations:*

a. *α-rays:* i.e., positively charged nuclei of helium atoms with a charge of $2 \cdot 4.8 \cdot 10^{-10}$ E.S.U.; velocity up to $2 \cdot 10^9$ cm/sec; penetration distance in air 3-8 cm, creating $10^5\text{-}3 \cdot 10^5$ ions per α particle;

b. *β-rays:* i.e., electron rays with velocity up to 99.6% of velocity of light; electric charge $= 4.8 \times 10^{-10}$ E.S.U.; mass $9.1 \cdot 10^{-28}$ gram, penetration distance in air abt. 100 × more than α rays, creating abt. 100 × less pairs of ions; comparable to *cathode rays;*

c. *protons:* i.e., hydrogen nuclei moving at high speed; they are not emitted by radioactive substances but are obtainable also as a beam from a cyclotron (see also RUSSELL effect, p. 45); their ionization capacity is intermediate between α and β rays;

d. *deuterons:* i.e., nuclei of the heavy isotope of hydrogen, deuterium;

e. *neutrons:* a penetrating radiation composed of collapsed hydrogen atoms, i.e., pairs of embedded protons and

electrons, forming electrically neutral corpuscles; they originate if, for example beryllium is bombarded by α particles; having no charge they do not lose energy by ionization of material and are only affected by collisions with the heavy atomic nuclei; neutrons which penetrate a nucleus may be absorbed and cause emission of a proton, α particle and one or more neutrons;

f. *mesons:* electrically neutral particles with a mass of 100-200 $\times$ the mass of an electron (acc. to NEDDERMEYER and ANDERSON) composing the most penetrating compound of cosmic rays; after 10^{-6} sec they disintegrate into *neutrinos* (hypothetical particle without a charge and with a mass similar to an electron).

2. *Cosmic rays:*
   a. *corpuscular electron ray:* emanated by the sun, particularly during sunspot-periods, causing polar light phenomena;
   b. *cosmic rays sensu stricto:* intensity increases in the atmosphere at great height and with increasing latitude; composed of *positrons* (positively charged electrons, originating also during materialization of penetrating γ rays) and *mesons.*

The action of all these kinds of different radiations is the result of their power to dissipate energy in organic tissues. Three kinds of fundamental processes can be distinguished: ionizing of atoms without appreciable change in temperature, excitation and energy transfer accompanied by heating.

I. *Ionizing of atoms:* the so-called *ionizing radiations*, such as X-rays and radioactive radiations, have sufficient energy to separate electrons of atoms or molecules. It has been found that a dosage of X-rays of 10^5 *Roentgen*[1] raises the temperature in tissues only 0.25° C, which seems inadequate to explain the great biological effect of ionizing radiations. According to LEA a.o. the effect is probably due, not to the separation of electric charges as such (a result of the ejection of electrons) but to chemical changes of the molecule to which the atom belongs. These chemical changes are explainable as follows:

a. the removal and breaking up of electron bonds lead to changes in chemical behaviour;

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[1] *Roentgen* is the quantity of X- or γ-radiation such that the associated corpuscular emission per 0.001293 g of air produces in air ions carrying 1 E.S.U. of electricity $= 2.082 \cdot 10^9$ ion pairs per cm³ of air at 0° C and 760 mm pressure, involving an energy dissipation of 0.1083 erg/cm³ of air. A similar unit is also used for β and α rays.

The energy of electro-magnetic waves can be calculated with the formula $E = \dfrac{12400}{\lambda \text{ (in A.U.)}}$ electron volts.

b. the energy involved in ionization (= 10 electron volts or upwards, 1 eV = $1.602 \cdot 10^{-12}$ erg) exceeds the energy required to remove an atom from a molecule.

The energy involved in attachment of an electron to an atom, i.e., the formation of a negative ion, is usually less than the energy required for the removal of an electron (positive ion).

The biological effect of ionizing radiation depends on two processes:

A. primary ionization;

B. secondary ionization:

α. if an electron ejected at a primary ionization has an energy of several hundred or thousand electron volts, it can travel an appreciable distance and produce a large number of secondary ionizations. The secondary ejected electrons form separate tracks branching off the main track and are called δ rays; their energy often exceeds 100 eV and makes them biologically very important.

β. Electrons existing in tissue are often projected at high speeds by x and γ rays, producing secondary ionization; β rays and cathode rays can do the same. But even non-ionizing radiations such as ultra-violet light can eject electrons; this occurs freely. It is known — particularly concerning metals — as the HALLWACH *effect*, after the discovery of HALLWACH in 1888 that when ultra-violet light falls upon the negatively electrified surface of a sheet of zinc, the surface rapidly loses its negative charge due to electron emission.

These *photo-electric phenomena* follow certain rules:

1. the velocity of the electrons emitted is independent of the intensity of the light and depends only upon the frequency of the incident light (the shorter the wave-length the greater the emission, except with alkali metals which show max. photo-electric effect with light belonging to the visible part of the spectrum);
2. the rate of emission is directly proportional to the intensity of the light;
3. the plane of polarization of the incident light influences also the rate of emission;
4. the emission ceases when the electric charge produced by the loss of negative electrons is sufficient to prevent further escape of electrons or if all free electrons are released (so-called *photo-electric fatigue*);
5. longer waves can sometimes bring about a certain amount of recovery from photo-electric fatigue.

γ. Hydrogen nuclei (protons) already present in the tissue, when irradiated by fast neutrons are projected at high speed as proton rays (see RUSSELL effect p. 47); neutrons can also project carbon-, oxygen- and other nuclei.

II. *Excitation:* if an electron in an atom or molecule is raised to a state of higher energy, it proves to be a less drastic process than the ejection of electrons. This process is called "excitation" and is created by ultra-violet rays, and by all the ionizing radiations. Excitation, however, has less biological effects than ionization (see also p. 30, luminescence of crystals).

III. *Energy transfer accompanied by heating* (see also Bibl. No. 191

and 191a): if Hertzian waves of high frequency pass an electrolyte these may be a considerable increase in temperature. An electrolyte solution may be considered a condensor with a conducting solution as the dielectric and the two opposing surfaces as plates (see Bibl. No. 199, p. 1085). If an alternating potential is impressed on the dielectric, the bound electrons are displaced, first in one direction and then in the other.

Overcoming the forces within the dielectric requires energy; this loss of energy manifests itself as heat, the so-called *dielectric hysteresis loss.*

If the rise in temperature of an electrolyte, placed within a coil of 4 turns, using a frequency of 11.4 megacycles/sec and a current of 10 ampère, for 5 minutes, is taken as 100% for the concentration of 0.85 g NaCl per 100 g solution (isotonic saline solution), it was found that at a concentration of 0.1 g NaCl per 100 g solution the relative rise in temperature was 11.6%, at 1 g NaCl/100 g sol. it amounts to 118%. In other words in the induction field heating is usually produced in an electrolyte in direct proportion to the concentration and conductivity of the latter. In dilute solutions conductivity might increase considerably, due to greater dissociation of molecules causing an increased heat production, which decreases again at a very high diluting stage (conductivity of pure water being very small). SCHLIEPHAKE (Bibl. No. 688) could demonstrate that Hertzian waves with wavelength of 3.5 meter created max. heating in a NaCl solution at a concentration of $^1/_{40}$ normal; with $\lambda = 34$ m at $^1/_{400}$ N; with $\lambda = 98$ m at $^1/_{1000}$ N. In other words max. heating is obtained in smallest concentrations with largest Hertzian waves. The body fluids of animals are heated mostly with λ smaller than 20 m; blood plasma (see p. 77) with $\lambda = 2.5$—2.8 m; blood with $\lambda = 3$—3.7 m (in 3 minutes increase in temperature of 10.5° C). According to PFLOMM irradiation of a RINGERS solution (physiological salt solution composed of 0.8% NaCl, 0.2% KCl and 0.02% $CaCl_2$) with $\lambda = 4.2$m increases the temperature from 24.5° C to 37.1° C.

In the case of a body made of materials of various conductivities, such as a living organism, heat will be produced at the greatest rate in materials of highest conductivity, i.e., vacular tissues. Heating will be considerably less in fats and other tissues of low conductivity.

(This can be demonstrated by using air-spaced electrodes, with an air-space of 1-2 inches between tissue and electrode, frequencies of 40-50 megacycles corresponding to radiation wave-lengths of 7.5-6 m).

In view of the great importance of these different processes in the explanation of divining phenomena they are dealt with more in detail.

The mechanism of the action of ionizing and exciting radiations:

We have seen that the ionizing effect of radiations is created by electrons, protons and α particles which pass through tissue in paths; these paths may be taken as straight for distances of a few microns. Passing the tissue the particles lose energy as a result of collision with atoms. Consequently, nearly all energy dissipated by ionizing radiations is ultimately degraded into heat-energy. The biological effects created by X-rays and ultra-violet rays (which are not able to ionize; they can only excite) differ not only in their ionizing behaviour but also in the way they are absorbed by other substances.

Ultra-violet rays have little biological effect above 300 mμ. The influence

depends on the absorption coefficient of the protoplasm or other absorbing substances. The *absorption coefficient* depends on the molecular structure of the irradiated material and is different for example, for nucleic acid and proteins. As the ratio of these components vary for different parts of chromosomes and during different stages of the division cycle, the dose in erg/cm^3 absorbed energy may differ considerably in each case. The crystalline structure of the micellae (see p. 9) and the luminescence phenomena of crystals (see p. 30) make these irradiation phenomena even more complicated.

X-rays, however, are rather independent of the chemical combination of the absorbing atoms. Only near to bones — containing atoms of elevated atomic number — does stronger absorption take place, but in normal tissue the differences are slight.

A third difference between ultra-violet rays and the ionic radiations is the *distribution of dissipated energy*. During ultra-violet irradiation the excited atoms are distributed at random and there is no tendency to form groups as each excited atom is produced by complete absorption of a single quantum of light. With ionizing radiation, however, the ions are localized along the paths of the ionizing particles and are concentrated in clusters.

The *effect of ionizing radiations on dilute aqueous solutions* is of great importance to biological processes. Experiments of FRICKE, HART, and SMITH (Bibl. No. 198a) demonstrated that the action of radiation on dilute aqueous solutions are indirect actions, i.e., most of the molecules of the solute which react are not excited or ionized directly by the radiation; their reaction follows excitation or ionization of the solvent molecules. As a result the weight of a solute, reacting on a given number of "roentgens", is independent of the concentration, i.e., the amount of solvent; it depends only on the dose of irradiation. For example, 25 micromoles of hydrogen are liberated per litre of a solution of formic acid with 10,000 r of X-rays, irrespective whether the solution contains 10^{-4} or 10^{-1} g mol. of formic acid per litre; also, the dose required to inactivate a given weight of enzyme is approximately the same in different solutions. The processes in the solvent are explained by LEA as follows: to convert a water molecule into H and OH radicals only 5 eV is required (= 115 kilocalories per g mol.). If an electron is ejected from the H_2O molecule it may split in H and OH radicals. Oxidation of organic compounds means absorption of the OH radicals and as a result the H radicals accumulate and combine into gaseous hydrogen. OH radicals are highly reactive as electron acceptor; this explains that almost all organic compounds are decomposed by irradiation in aqueous solutions. However, if present in sufficient concentration, organic compounds can act as protective agents; this is particularly important for the stability of certain colloidal structures.

The problem of marked biological effects by doses of irradiation which produce only a small degree of chemical change:

A dose of $5 \cdot 10^5$ roentgen produces abt. 10^6 reacting molecules. The number of atoms in $1\mu^3 = 10^{11}$, in other words only a small percentage is chemically changed. However, it was found that a small overall percentage of chemical change can be effective by one or a combination of the following processes (see Bibl. No. 207):

1. *Formation of cell-poisons:* very low concentrations of decomposed proteins, etc., are probably poisonous to other vital components of the cell;

2. *Activated water reactions:* a dilute solution of enzymes can be inactivated by the action of OH or H radicals of water (see above) by doses which would be practically inactive in a concentrated solution. As enzymes occur in low concentrations in cells, enzyme destruction is important in case of irradiation. Nonetheless, protective action of other organic agents in the cell (see above) decreases this effect.

3. *Direct action on large molecules:* the dose required to produce a chemical change in a given proportion of the molecules of a substance by direct action is inversely proportional to the molecular weight supposing that the ionic yield is constant. Roughly 10^6 R produces a chemical change in half the molecules of a substance of molecular weight 10^6. *Viruses* (see p. 11) have a very high molecular weight. The dose required to create chemical action is thus small compared with other molecules.

4. *Localization of ionization:* although an overall chemical change may be small in the immediate neighbourhood of the path of an ionizing particle, practically every solute molecule may be affected. If the changes take place in a particular structure, which is vital for the cell as a whole, biological effects (e.g., breakage of a *chromosome*, see p. 12) might be created by radiation if a densely ionizing particle passes through it. Those breaks can be observed under a microscope, the location of the breakage being mainly determined by the space-lattice structure of the micella crystals. The same influence can occur if molecules, especially of the *genes* (see p. 12), are chemically changed, which might be the cause of spontaneous mutations during irradiation. It has been possible also to calculate the size of molecular structure affected by a given dose of radiation (so-called TARGET *theory*). It has been found, for example, that the sensitive zone in a cell which can be destroyed by 1β particle is only $2 \cdot 10^{-16}$ cm^3, containing abt. 10^7 molecules.

5. *Spread of the ionization effect:* a very large number of chain molecules occur in a chromosome thread of Tradescantia of abt. 0.1μ.

Although only a small fraction is broken by direct ionization, some spreading effect occurs by transference of energy from one molecule to another, either as heat (*point-heat theory of* F. DESSAUER and P. JORDAN; see Bibl. No. 194a and 204a) or by the production of active radicals in the water inside the chromosomes (*theory of* L. H. GRAY). The latter process takes place at distances of 15 mμ from the path of an ionizing particle.

The mechanism of the action of high frequency Hertzian waves: According to SUMMERS and HUGHES (Bibl. No. 212) there appear to be two modes of energy transfer by which a high frequency field may affect tissues:

1. by heating of protoplasm, the medium surrounding it, or both; various structures are affected differentially depending upon the frequency, dielectric coefficient and conductivity of the medium (see above);
2. through an electric mechanism that depends upon the presence in the organism of free charges, or chemicals with dipole moments[1]. Forced electro-magnetic vibrations may lead to observable permanent changes in the internal organization of the tissues:
   a. in a homogeneous field of sufficient intensity a small dipole may oscillate longitudinally without translation, i.e., it may alternately elongate and contract;
   b. in an inhomogeneous field the dipole movements are both longitudinal and translational; in translational vibration the dipole as a whole moves small distances on either side of its mean position. These vibrations are so-called "free oscillations" or "resonances".

The main natural sources of ionizing and exciting radiations:

The sun-energy received at the earth's surface is profoundly modified by scattering (produced by molecules of the earth's atmosphere, water vapour and by dust) and by absorption (produced by atmospheric gases and vapours, notably water vapour [increase of 1 mm in water vapour pressure decreases radiation intensity by 2%], ozone, oxygen and carbon dioxide). It varies with the position on earth, the time of the year,

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[1] In conducting substances the electron is detachable from the atom; in dielectrics it cannot be liberated. The effect of an electric field upon the latter is to displace the positive charge of the atom nucleus in the direction of the field and the negative outer charge in the opposite direction. These displacements are limited by the forces that bind the charges to the atom. Each atom is changed by this internal elastic disturbance in a *dipole* or *electric doublet* and has an *electric moment*, analogous to the magnetic moment of a small magnet (= strength of the magn. poles multiplied by the distance between the poles or the couple required to maintain a magnet at right angles to a magnetic field of unit strength). Such a dipole produces an electric field n its neighbourhood.

the altitude, temperature, atmospheric pressure, cloudiness, covering of the ground, etc. If the sun approaches the horizon and the mass of air traversed by the solar beam increases, the atmospheric losses also increase. The solar energy received on earth also changes, due to long-period fluctuations (caused by changes in the solar activity itself; to changes in the inclination of the axis of the earth, a period of 40,400 years; to changes in the excentricity of the ecliptic, a period of 91,800 years) and to short-period fluctuations (caused by obscurations in the solar atmosphere which, rotating with the sun, produce depressions whenever they point towards the earth, etc.). The sun radiation is subjected to the phenomenon of *polarization* (see appendix pag. 435). RAYLEIGH demonstrated that scattered light in a dusty atmosphere is polarized. Light coming from the blue sky is also partially polarized, particularly in a region 90° from the sun (discovered by ARAGO in 1809). Light coming from a point 160° from the sun (ARAGO point), 20° above the sun (BABINET point) and 20° below the sun (BREWSTER point) is unpolarized. The degree of polarization depends mainly on the sun's altitude, the wave length of the light examined, the degree of turbidity of the atmosphere and the general weather conditions. These polarization phenomena might have particular biological effects. All these variations in sun energy produce changes, particularly in the shorter waves of the sun spectrum and as the human body (and consequently the divining phenomena, particularly dowsing) is considerably influenced by these changes, a further discussion is apposite.

The influence of ground cover is very important: snow, proximity of water or ice increases the reflected sunray-energy, particularly of the shorter ultra-violet rays; reflection of ultra-violet from the surface of water is about twice that from a field of grass, while reflection from snow is 4 times that from water and twice that from sand; severe sunburn on snow or ice in mountains is due to this increase of ultra-violet radiation as a result of increased altitude and increased reflexion.

Ozone plays an important role in radiation phenomena. The amount in the atmosphere is greatest at high altitude, and greater in spring than autumn, the maximum occurring during low atmospheric pressure. Its importance is due to power of absorption and selectivity of wavelengths absorbed. The ultra-violet limit in the solar spectrum is fixed by the ozone of the stratosphere.

Water vapour creates a selective absorption of radiations with wavelengths longer than 800 mμ (i.e., infra-red). On a clear but humid day, absorption is generally less than 15%. But it absorbs almost completely the terrestrial radiation ($\lambda = 4$ - 50μ). The upper surface of a cloud reflects 78% of the incident solar radiation. Reflection at the lower surface increases ultra-violet radiation.

Dust in the atmosphere scatters terrestrial radiation and reflects little. Solar radiation is both scattered and reflected. In summer, the ultra-violet in cities at street level, can be 20% less than in open country.

The geographical position on earth influences the amount of ultra-violet, which is greatest in the tropics and diminishes with increasing latitude (because of diminishing solar altitude and increasing ozone). The radiation intensity per unit of time, however, often differs very little. High humidity and much dust in the tropics (e.g., Indonesia) creates an intensity which is not even as great there as at midday in June on the North Sea coast. Dust in dry desert regions lowers the intensity considerably.

Diurnal and seasonal variations: the amount of ultra-violet received at midday is higher than in fore- and afternoon, in summer higher than in winter. The diurnal variations in winter of shortest ultra-violet waves are 306-312 mμ, in summer 296-320 mμ; seasonal variations at midday are 296-309 mμ.

Summer midday sun is 10% richer in infra-red than in winter, in the red 45%, in the green 90%, in the blue-violet 250%, in the ultra-violet 1,000%.

Spring sunlight is richest in infra-red; autumn light is comparatively richer in ultra-violet.

Altitude factor: ultra-violet radiation (particularly smaller than 320 mμ) increases with the altitude. However, as scattering of light in a perfectly dry and dust-free atmosphere is inversely proportional to the fourth power of the wave-length, ultra-violet radiation increases relatively much more in scattered daylight (so-called skylight) than in direct sunlight, the skylight away from the sun being sometimes 20% richer than the skylight in the direction of the sun.

Intensity of sunlight: at the boundaries of our atmosphere the sun-radiation has a mean intensity of 1.94 cal per sq. cm per min, with a maximum in the blue at 4,700-4,800 Å. At the surface of the earth, with the sun moderately high, the intensity is 1.0-1.5 cal per sq. cm per min, of which the ultra-violet represents 1-5%, the luminous part 41-45% and the infra-red 52-60%. As the sun sinks lower, the ultra-violet decreases, while infra-red increases (in winter with sun at 20° practically no ultra-violet reaches the earth), but the max. shifts towards the longer waves, creating a decrease in temperature. With the sun high and on a very clear day only 50% of the sun-energy reaches the earth at sea level, 75% at a height of 1.880 m.

The direct biological effect of the sun's rays greatly depends on the depth of penetration in the skin (see Bibl. No. 182). Maximal penetration in human skin occurs at 750 mμ, and is 99% absorbed after penetrating a few mm. Wavelengths shorter than 320 mμ do not penetrate more than 0.1 mm. However, such radiations can penetrate the whole of the mono-cellular organisms. The main processes created by sunray irradiation can be summarized as follows:

1. An immediate reddening of the skin during and after irradiation, due to radiant heat (infra-red), which activates the vascular tissues,

the heat producers of the living body and which increases the amount of blood in the skin — so-called *heat-hyperemia.*

2. After a latent period of an hour or more it is followed by the action of ultra-violet rays which might cause an *erythema* (a red inflammation) or even aggregation of colloidal particles of the skin, if the wavelength is less than 315 mμ, with maxima at 296 and 245 mμ; longer waves (max. at 385 mμ and 408 mμ) also create erythema. Erythema is the observable manifestation of dilation of the minute blood vessels in the dermis, a secondary process due to primary photo-chemical action; it liberates a histamine-like substance as a result of excitation of the cells of the epidermis. This substance diffuses to and acts on the blood vessels just beneath.
3. The *tanning process* is very complicated and only partially understood. According to HENSCHKE and SCHULZE (see Bibl. No. 202), EDWARDS and DUNTLEY (see Bibl. No. 196) this process has two major components:
   a. a photo-chemical process comparable to the erythema process (see above);
   b. a process that starts before erythema appears and begins immediately on exposure to sunlight. It is a process that requires oxygen, which is not the case in the previously mentioned photo-chemical process. The colouring is probably due to oxidation of *melanin pigment* in the epidermis, a process accompanied by a thickening of the corneum, the superficial horny layer acting as a screen for further irradiation by short waves.
4. The *photo-chemical action* of sunlight transforms certain sterols in vitamin D3, ergosterol in vitamin D2, etc., which have antirachitic properties.
5. *Presence of fluorescent dyes* in the skin of living organisms, e.g., by absorption of certain food compounds, are able to sensitize them to light, the dye acting as a light absorber for a certain kind of photo-chemical reaction. This phenomenon is known as *photo-dynamic action of* RAAB *and* TAPPEINER (see Bibl. No. 187 and 208) and is of great importance to divining phenomena. The wide variety of chemical structures in the photo-dynamic compounds indicates that the dye molecule itself does not undergo specific alteration during the photo-dynamic action. The effectiveness of a given dye (*photo-dynamic effectiveness*) depends on the extent and manner of uptake of the dye by the living system and not on differences in photo-chemical mechanism. A fundamental difference between photo-dynamic action and erythema is that erythema is independent of the presence of O_2, whereas according to BLUM (see Bibl. No. 187) photo-dynamic processes take place only when O_2 is present. It was also found that external contact of the skin to photo-dynamic compounds, particularly when applied in fatty base, photo-sensitizes the skin, due to adsorption of these substances. Several substances are known to create this phenomenon, e.g., coal

tar products, such as anthracene, acridine, phenanthrene compounds, etc. (see Bibl. No. 189). Contact with certain plants might also cause photo-sensitization, e.g., meadow plants (probably due to furocumarin compounds), parsnip (pastinaca sativa), figs, dictamnus albus, perfumes containing oil of bergamot or citron oil, etc. These phenomena, together with the RUSSELL effect (see p. 33-48), are of significance in the discussion on radiesthesia phenomena. A great number of organic substances are fluorescent and act as photo-sensitizers. As a matter of fact most proteins are fluorescent, a property possibly dependent on benzene ring nuclei. Hydrolysis of proteins by enzymes or alkali does not greatly increase fluorescence but acid hydrolysis results in strong blue-green fluorescence. Chlorophyll has red fluorescence; porphyrin derivates (which derive from hemoglobin) show fluorescence even at concentrations of 10^{-8}. A long list of photo-sensitizers was prepared by METZNER (see Bibl. No. 208). Many drugs, such as arsenic quinine sulphate, different alkaloids, etc., are fluorescent in concentrations of 10^{-7}; e.g., quinine fed to a nursing mother can be detected by fluorescence in the urine of the child. The pH concentration of the surrounding fluids greatly influences the fluorescence phenomena of drugs. Enzymes in water and some vitamins are also fluorescent (see Bibl. No. 192, 193, 203, 211, 213).

6. Certain substances (e.g., sulphanilamide), if absorbed by the living organism, create a great photo-sensitivity which, according to BLUM and EPSTEIN (see Bibl. No. 188 and 198), is not due to an ordinary photo-dynamic process. External treatment e.g., with green soap, may sensitize the skin to wavelengths shorter than 320 mμ.

7. According to PORTER and WYMAN, exposure to X-rays of mono-molecular layers (see p. 18) creates a large negative potential, while heating lowers the contact potential. Irradiation with ultra-violet tends to decrease the thickness of the layers (according to SCHAEFFER). These effects are formed only in special circumstances.

Varying biological sensitivity to sunray energy:

It was observed by ELLINGER (see Bibl. No. 197) that blonds are more sensitive to sunburn than brunettes; men seem to be more sensitive than women, persons between 20 and 50 more than younger or older people. There are two seasonal sensitivity maxima: in March-April and October-November. An unstable nervous system, overactive thyroid gland, elevated blood pressure, active tuberculosis also increase the sensitivity. During pregnancy the sensitivity increases in the first 7 months, after which it diminishes somewhat, though still high at term. Certain people are extremely sensitive only to a certain small wave-length interval, which can be created by direct irradiation; indirect or reflected sunrays, etc., might also create skin disturbances and intense

itching if people possess this local photo-sensitivity (*photo allergic phenomena*).

It has been found that for the average person the minimum dose that creates erythema is $20\mu w$ per cm^2 of radiation, of wave-length 296 $m\mu$, acting for 15 minutes, i.e., $1.8 \cdot 10^5$ erg per cm^2 total. HARDY and OPPEL (Bibl. No. 200) showed that the smallest rate of radiation the body is capable of perceiving as warmth is 0.00015 gcal/cm^2/sec. Sensation is evoked in 3 sec by exposure of 200 cm^2 of surface to such a stimulus, i.e., the total energy exchange for heat sensation is 0.09 gcal.

Influence on cancer:

According to BLUM (see Bibl. No. 186), wavelengths smaller than 320 $m\mu$ in sunlight are often of great importance in the development of cancer.

He based this statement on the following observations:

1. mice, which have a much thinner epidermis than man, often develop tumours of the skin by continuous irradiation with sunlight or mercury arc radiation;
2. cancer of the skin is most common in regions that receive most sunlight, presumably regions with low latitude and little dust and water vapours in the atmosphere;
3. cancer of the skin is principally distributed over parts of the body regularly exposed to sunlight. Over 90% occurs on the face;
4. cancer of the skin is rare amongst negroes and other dark-skinned races whose pigment protects them;
5. cutaneous cancer is more common amongst outdoor workers.

Influence on sexual glands:

According to ROWAN (Bibl. No. 210) and BISSONETTE (Bibl. No. 185) light exerts influence on the sexual activity of vertebrates. Seasonal migration of birds might be related to this problem. MYERSON and NEUSTADT (Bibl. No. 209) reported that mercury-arc radiation applied to the skin causes increased androgen excretion in man. *Androgens*, like *testerone* ($C_{19}H_{28}O_2$) occur in testicular substance and are believed to be one of the important sexual hormones. BENOIT (Bibl. No. 184) discovered effects by irradiation of animals.

The previous discussions represent only a brief summary of the enormously complex problem of the influence of electro-magnetic and radio-active radiations on solutions, colloids and living organisms in particular. They are of fundamental importance in the understanding of divining phenomena. More details concerning this problem are given in following chapters.

IC. 1. c: Sensitivity of electrolytes and organic substances to magnetic fields (see table p. 27, Bibl. No. 214-259)

The influence of magnetic fields on organic substances in general, and living matter in particular, has proved to be of great importance during dowsing phenomena (see chapter III). It is therefore advisable to discuss the fundamental processes of these phenomena; this will also facilitate the discussion in the chapter on the geophysical field (p. 206).

Different magnetic properties of materials and physical units:

It is well known that all materials may be classified as *diamagnetic*, *para-magnetic* or *non-magnetic*, depending on whether they repulse, attract or are neutral to the magnetic lines of force (see fig. 6). The ratio of the *magnetic flux* (i.e., the number of lines of force per unit area) inside a body to the flux in vacuum for a given applied field is defined as the *magnetic permeability* of that body ($= \mu$). For air and all other so-called non-magnetic materials $\mu = 1$. For para-magnetic substances μ is greater than 1. There is a small class of substances in which the magnetic permeability is vastly greater than for any other substance. They are called *ferro-magnetic* materials.

Instead of permeability the *magnetic susceptibility* ($=$ K) is used as a unit. It is defined as the ratio of the intensity of magnetization or the magnetic moment (I) per unit volume, to the magnetizing force or field-strength (H). $K = I/H$. K is rather constant and essentially dependent of H, except in the case of highly magnetic materials, such as iron, or magnetic minerals, such as magnetite. It may be proved that $\mu = 1 + 4\pi K$.

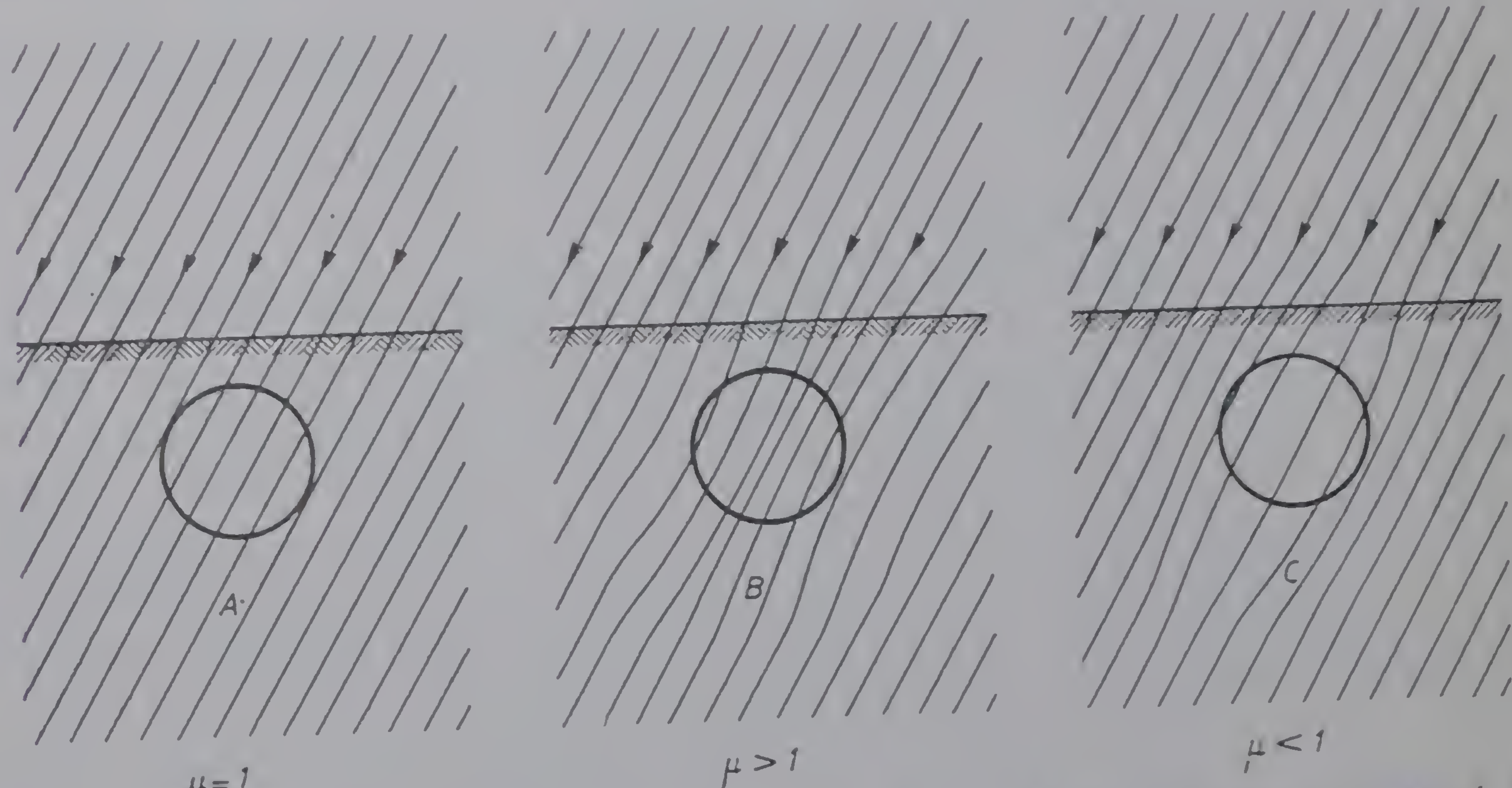

Fig. 6: (Bibl. No. 608, fig. 6) Distortion of the lines of force of a magnetic field due to various materials: A) non-magnetic material; B) para- or ferro-magnetic material; C) diamagnetic material.

The deeper cause of the distinction between para- and diamagnetic substances.

This was explained for the first time by P. Langevin in 1905 with the electronic theory. An electron rotating in a circular orbit around the atom nucleus is equivalent to a circular current creating a magnetic field. Most atoms contain several electrons, and the orbits may be so directed that the resultant magnetic moment for the atom is zero. A magnetic field would have no directive effect upon such an atom. When, however, the resultant magnetic moment is not zero, e.g., because one of the electrons is not compensated by another rotating in the opposite direction, the atom possesses a resultant magnetic moment and consequently possesses energy in a magnetizing field. The orientation of the electron orbits will be such as to cause an increase in magnetic induction. The permeability of the substance will be greater than unity and its sus-

ceptibility positive (para-magnetic substances). When the resultant magnetic moment of the atom is zero, the magnetic field has no directive effect, though it influences the electronic orbits. This creates a decrease in magnetic induction (diamagnetic substances), the magnetic permeability being less than unity and the susceptibility negative.

In most heterogeneous materials (e.g., rocks), the outer magnetic condition is determined by the relative magnetic susceptibilities of the different components (minerals). The effective susceptibility depends on those individual constituents and on the percentage of each. Because of the high susceptibility values of ferro-magnetic substances, traces of these materials in a diamagnetic medium can create a para-magnetic effect.

Magnetic constants of different substances:

1. *Inorganic substances:*

Ferro-magnetic substances are the metals iron, nickel and cobalt and the minerals ilmenite ($FeTiO_3$), pyrrhotite (FeS) and magnetite (Fe_3O_4); the mineral chromite ($FeO.Cr_2O_3$) can become ferro-magnetic by weathering and the formation of magnetite.

Para-magnetic substances are the metals Al, Pt, K, Mn and oxygen. Important para-magnetic minerals are limonite ($Fe_2O_3.nH_2O$), manganosite (MnO), pyrite (FeS_2), rutile (TiO_2, tetragonal crystal), pyrolusite (MnO_2), brookite (TiO_2, rhombic crystals), hematite (Fe_2O_3), hausmannite (Mn_3O_4), cuprite (Cu_2O), a.o.

Diamagnetic substances are e.g., the elements Cu, Au, Bi, Pb, Ag, Hg, sulphur and hydrogen; also water and the minerals anhydrite ($CaSO_4$), rocksalt ($NaCl$), calcite ($CaCO_3$), graphite (C), quartz (SiO_2) a.o.

The accurate susceptibility values are[1]:

Ferro-magnetic substances

iron	$80{,}000 \cdot 10^{-6}$
magnetite	$32{,}122 \cdot 10^{-6}$
ilmenite	$4{,}400 \cdot 10^{-6}$

Para-magnetic substances		Diamagnetic substances	
hematite	$426.00 \cdot 10^{-6}$ (max. value)	anhydrite	$-1.12 \cdot 10^{-6}$
manganosite	$349.44 \cdot$,,	rocksalt	$-0.82 \cdot$,,
hausmannite	$318.07 \cdot$,,	calcite	$-1.00 \cdot$,,
pyrolusite	$131.22 \cdot$,,	graphite	$-8.00 \cdot$,,
pyrite	$120.00 \cdot$,,	quartz	$-1.20 \cdot$,,
limonite	$57.00 \cdot$,,	copper	$-0.09 \cdot$,,
cuprite	$4.38 \cdot$,,	gold	$-0.15 \cdot$,,
rutile	$0.28 \cdot$,,	bismuth	$-1.38 \cdot$,,
platinum	$1.1 \cdot$,,	lead	$-1.30 \cdot$,,
aluminium	$0.65 \cdot$,,	silver	$-0.20 \cdot$,,
potassium	$0.52 \cdot$,,	sulphur	$-0.85 \cdot$,,
oxygen	$0.139 \cdot$,,	mercury	$-0.19 \cdot$,,
air	$0.029 \cdot$,,	water	$-0.72 \cdot$,,
		hydrogen	$-0.002 \cdot 10^{-7}$

The average susceptibilities of rocks are: for nepheline basalt (rich in magnetite) $6{,}000 - 10{,}000 \cdot 10^{-6}$; olivine gabbro $5{,}600 \cdot 10^{-6}$; dolerite

[1] based on S. G. STARLING: Electricity and magnetism p. 565 (1941); J. J. JAKOSKY: Exploration Geophysics (1940).

2,600 - 5,400 $\cdot 10^{-6}$; serpentine 2,500 $\cdot 10^{-6}$; granite 650 - 1,350 $\cdot 10^{-6}$; basalt 600 $\cdot 10^{-6}$; diabase 470 $\cdot 10^{-6}$; dolomite 0.9 - 11 $\cdot 10^{-6}$; marble - 0.75 $\cdot 10^{-6}$ (based on tables of H. REICH: *Erdmagnetismus und glaciales Diluvium, Jahrb. preuss. geol. Landesanstalt*, 46, 1925, p. 249-291)

The difference in the susceptibility of minerals is used in metallurgical processes to separate (with an electro-magnet) the iron-containing minerals such as pyroxenes, amphiboles, olivine, garnet, etc., from felspar, leucite, nepheline, etc. These iron-containing minerals become even strongly para-magnetic after heating.

According to MILNE (Bibl. No. 239a) the para-magnetic minerals can be divided as follows:

a. strongly magnetic minerals, separable with a bar magnet (magnetite, pyrrhotite);
b. moderately magnetic, separable with a horse-shoe magnet (augite, biotite, cassiterite, chromite, cordierite, garnet, glauconite, hematite, hornblende, ilmenite, picotite, sphalerite);
c. weakly magnetic, sometimes only separable with strong horseshoe magnets (actinolite, ceylonite, chlorite, chloritoid, diopside, epidote, hypersthene, marcassite, monacite, muscovite, olivine, pyrolusite, staurolite, tourmaline).

The minerals augite, garnet, hypersthene, muscovite and sphalerite are liable to great variation in magnetic property.

It was found by F. HENSLER in 1903 that it is possible to produce a magnetic alloy of non-magnetic substances. An alloy composed of 58.9% Cu, 14.6% Al and 26.5% Mn has a permeability of 225 $\cdot 10^{-6}$. FLEMING (Bibl. No. 230) described an alloy of 60.49% Cu, 11.65% Al and 22.42% Mn which exhibited magnetic properties identical to those of a feebly ferro-magnetic material. Traces of chromium, tungsten or manganese increase considerably the magnetic properties of steel, while 12% of manganese renders it almost non-magnetic at low fields ($\mu = 1.4$).

2. *Organic substances:*

A great number of experimental studies have been carried out but were for the most part forgotten as they took place in the previous century. A short summary of the different results is therefore not superfluous.

FARADAY (Bibl. No. 228) found in 1845 that blood is a diamagnetic fluid notwithstanding the iron contained in the colouring matter; the red muscular fibre of beef or mutton are not para-magnetic. The majority of plants, according to FARADAY, are diamagnetic.

BRUNNER and DE LA RIVE (Bibl. No. 223) discovered in 1847 that a bound-up frog suspended between the poles of an electro-magnet assumes an equatorial position (see p. 78), indicating that the complex animal organism as a whole is diamagnetic, probably due to the fact that water enters so largely in its composition. BRUNNER's observation was confirmed later by DUBOIS-REYMOND in 1867 (Bibl. No. 219).

PLUCKER (Bibl. No. 246) confirmed FARADAY's experiments in 1848; he found that blood of the frog, man and the ox are diamagnetic; he discovered also that the blood corpuscles are more strongly diamagnetic than the liquid in which they float.

KOHLRAUSCH (Bibl. No. 235) demonstrated in 1887 that dried meat is diamagnetic, in other words the diamagnetic property of water

is not apparently responsible for the diamagnetic behaviour. The hand of a man is also diamagnetic, according to KOHLRAUSCH.

GAMGEE (Bibl. No. 232) in 1900 studied the magnetic properties of crystalline blood colouring matter. Blood is composed of an almost colourless liquid, the *blood plasma* and floating *blood cells*. The latter are composed of red coloured blood-cells, called *erythrocytes* or *chromocytes* (abt. 5,000,000 per c.m.m.) and the white colourless bloodcells or *leucocytes* (abt. 1 leucocyte on 300 - 400 chromocytes). The chromocytes are the smallest flat, roundish, slightly bi-concave discs. They are cells without a nucleus or surrounding cell-membrane and, with the help of the colouring substance of the chromocytes (called *hemoglobin*), can absorb oxygen from the air via the lungs.

Only a small amount of this substance occurs freely in blood plasma. Hemoglobin comprises 32% of the contents of erythrocytes, the remainder consisting of water (65%) and inorganic salts (3%). Hemoglobin is an iron-containing protein with a high molecular weight (abt. 68,000), with the general formula of $C_{758}H_{1203}N_{195}S_3FeO_{218}$ (in dog's blood). It is actually composed of *globin*, which is combined with a porphyrin derivate, *hematin* ($C_{32}H_{32}O_4N_4Fe$, according to NENCKI), to which the iron is attached. Both components are obtained by subjecting oxyhemoglobin to the action of acids or alkalis. Hemoglobin contains abt. 96% proteins and 4% *hemochromogen* (the actual colouring pigment, which contains 9% iron). In invertebrates it is often not the hemoglobin, but *hemocyanin* (a copper protein) which is the active substance. Any molecule that enters or leaves a chemical combination with hemoglobin must pass through the walls of the erythrocytes which are freely permeable to oxygen and CO_2 and to anions such as Cl, HCO_3, but not to cations such as Na and K (for the deeper causes see p. 141).

The ability of hemoglobin to combine reversibly with oxygen to become *oxyhemoglobin* depends entirely on the ferrous ions (normal blood with 15.4 g hemoglobin per 100 ml contains 0.05% iron). One atom of ferrous iron (Fe″) combines with one molecule of oxygen (O_2) or carbon monoxide. When the hemoglobin iron is oxidized to the ferric form (Fe‴) it loses its power to combine reversably with O_2 or CO. This is called *methemoglobin*, which cannot carry oxygen. It is obtained artificially by adding a few drops of a ferricyanide of potassium solution to oxy-hemoglobin.

CO_2 in the blood stream can combine partly (abt. 1/5) with the amino groups of hemoglobin and forms unstable carbamino or carbamate compounds ($CO_2 + RHN_2 \rightleftarrows RNHCOOH$). The remainder is carried as bicarbonate, practically all being formed inside the erythrocytes through the catalytic action of the enzyme *carbonic anhydrase*.

Hemoglobin as a protein, like all proteins, is able to act either as an acid or a base, depending upon the acidity of the medium. It is inactive at its isoelectric point, which is, for reduced hemoglobin, at pH = 6.8, for oxyhemoglobin pH = 6.65. Blood as a whole is nearly always slightly alkaline, the normal pH being 7.25. On the alkaline

side of their isoelectric points proteins (and hemoglobin) behave like acids and can combine with base.

This digression was necessary in order to understand the following discussions and to realize the complexity of the magnetic properties of blood, one of the fundamental constituents of the human body. In chapters II and III we refer to this summary of the physico-chemical properties of blood.

GAMGEE studied the fundamental magnetic properties of oxyhemoglobin, carbonic-oxide-hemoglobin, methemoglobin, hematin and acethemin, by suspending cakes of the dried crystalline bodies of abt. 18 mm in length between the poles of an electro-magnet; only hematin was examined in glass tubes.

GAMGEE obtained the following results:

1. *Oxy-hemoglobin* (prepared from horse's blood), as well as *carbonic oxide hemoglobin* and *methemoglobin* are strongly *diamagnetic* bodies (suspended in axial position, i.e., longitudinal axis of the body parallel to the line connecting both poles, the hemoglobin mass instantly assuming the equatorial position after the magnetic field is created, i.e., longitudinal axis perpendicular to the line connecting the poles of the magnet).
2. *Hematin* and *hemin* (also called *acethemin*, i.e., hydrochloride of hematin, created by decomposition of oxyhemoglobin by acetic acid in the presence of alkaline chloride), both prepared from ox's blood, are strongly *para-magnetic* bodies (suspended in equatorial position, they immediately assume an axial position after the magnetic field is put on).

GAMGEE explains this difference with the following observations:

1. In general the compounds in which iron and other magnetic metals are present in electro-negative radicals are diamagnetic.
2. During continued electrolysis experiments with solution of oxyhemoglobin (see p. 61) red colouring matter was sometimes precipitated on the anode, indicating electro-negative radicals.

In connection with the studies of GAMGEE the observation of TOWNSEND (Bibl. No. 251) is significant—that the susceptibility of ferric salts in solution seems to depend only on the quantity of iron ions per ml.

Other experiments on the magnetic properties of organic substances were made by EWART in 1902 (see Bibl. No. 227). He discovered that fragments of Primula, Narcissus, Helodea, Vallisneria and Chara suspended by a silk wire are para-magnetic.

This contradiction with FARADAY'S experiments (see above) was explained by EWART as being a result of the diamagnetic properties of water, cellulose and amylum, which occur in great quantities in several plants.

SSAWOSTIN (Bibl. No. 249) repeated these experiments in 1930 with Echevaria. Both in wet and dry condition it was pronounced dia-

magnetic. The same result was obtained with fragments of Begonia and Tulip. It was confirmed, however, that Helodea, Vallisneria and Chara are para-magnetic in aqueous surroundings.

ZWAARDEMAKER (Bibl. No. 259) had discovered in 1920 that milk, lymph and gall are diamagnetic substances, but less so than water. They can increase or decrease their diamagnetic properties, depending upon the content of para-magnetic oxygen.

WÖHLISCH (Bibl. No. 258), CLAMMANN (Bibl. No. 226) a.o. repeated these studies with different organic tissues in magnetic fields up to 12,000 Gauss. They were all diamagnetic, except celluloid and cocoon fibre, which were para-magnetic.

Finally we should like to mention the studies of CARDIN (Bibl. No. 225) in 1933, who discovered that erythrocytes of a calf, suspended in a serum of an isotonic sugar solution, move towards the south pole of a homogeneous magnetic field. The same experiment was repeated with particles of kaoline, clay and coal, but no magnetic migration could be observed.

The fundamental processes of the bio-magnetic effect:

A careful analysis of the different influences of magnetic field on living matter indicates that at least six fundamental phenomena are responsible for the complicated bio-magnetic effects.

1. Magnetostriction.
2. Magnetic properties of crystals.
3. Magnetic directive forces (see p. 57):
   a. of non-crystalline bodies
   b. of crystalline substances (e.g., micellae) creating, as a result of changes in orientation in solutions,
      α. changes in viscosity of the liquid*
      β. changes in resistibility of diffusing currents
      γ. changes in electric conditions
4. Influence on movements of ions and electrons in:
   a. liquids
   b. gases
5. magneto-chemical effect:
   a. magneto-electrolysis
   b. magneto-oxidation
6. induction of electric currents (changing internal distribution of electric potentials):
   a. influence on existing currents in non-moving bodies
   b. creating currents in moving, electric-conductive, components of a body.

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* See also experiments with "magnetic oil":
Light oil mixed with microscopic iron particles looks and feels like dirty crank case oil. But when placed in a magnetic field, the thin liquid suddenly thickens into a tough semi-solid.

Each of these fundamental phenomena is different in magnitude, depending upon the nature of the magnetic field applied: alternating (i.e., field alternating in direction), pulsating (i.e., fields regularly increasing and decreasing in strength) or constant, each of which is either homogeneous or heterogeneous. These fields create fundamentally different biological effects, depending upon the domination of one or more of the six basic phenomena.

Magnetostriction is the change in dimensions of a body when it is introduced into a magnetic field parallel to its length. It was discovered in 1886 by S. BIDWELL (see Bibl. 216a), who was able to measure changes of 10^{-7} of the length of the specimen. In ordinary fields this effect is very small and immeasurable, but with fields up to 300,000 Gauss KAPITZA (see Bibl. 234a) was able to measure these reversible changes for a number of substances. He found that *the relative change in length is proportional to the square of the applied field strength.*

If an initially unmagnetized rod of para-magnetic material is brought into an alternating magnetic field it will contract and expand with twice the frequency of the field; if the rod is initially magnetized, it will vibrate with the same frequency as the field. If the natural period of the premagnetized rod is the same as that of the magnetic field, the amplitude of vibration will be a maximum and since vibrations of the rod are longitudinal, sound waves might emanate from the ends of the rod (see also p. 108).

The *magnetic properties of crystals* are similar to those known in crystal optics, i.e., the imaginary surfaces connecting the points in a crystal with equal magnetic properties can be globes or ellipsoids (see Appendix). The latter are divided again into biaxial rotational ellipsoids, positive and negative respectively (in hexagonal, trigonal and tetragonal crystals), and triaxial ellipsoids (in orthorhombic, monoclinic and triclinic crystals). The globular equi-magnetic surfaces occur in so-called *magnetic isotropic* media and the ellipsoidal surfaces in *magnetic-anisotropic* substances. One distinguishes *permanent* and *induced magnetism*. The latter, in case of optical isotropic crystals, is the same in all directions. Optical uniaxial crystals (see appendix) are diamagnetic, biaxial crystals are trimagnetic. These magnetic properties are due to the space-lattice structure of crystals with ions at regular intervals on the material points in the lattice (see fig. 1) On page 30 we have discussed the FARADAY *effect* in crystals. It is evident that because of this complex magnetic behaviour of crystals, the micella crystals in the protoplasm (particularly of nerve cells) are influenced by a permanent magnetic field, if active for a long period.

The influence of *magnetic directive forces* has been considered on page 57 and can be passed over.

The *influence on movements of ions and electrons* is of great significance We have seen that during ordinary chemical processes and after irradiation (see p. 64) electrons and ions are created which determine most of the important properties of the living cell. Any influence on these electronic or ionic movements should therefore influence the living process if they are continued for long periods.

The influence of magnetic fields on movements of ions in liquids was studied by a small number of scientists.

URBASCH (Bibl. No. 254 and 255) pointed out that a moving ion with a certain electro-static charge is subject to a force in a magnetic field which depends upon the charge of the ion, the velocity of movement, the field-strength, the angle between direction of movement of the ion and the lines of force and the resistance which the ion experiences; the latter is dependent upon the viscosity and elasticity of the liquid. This last factor is of especial importance in organic colloidal substances.

URBASCH demonstrated this predicted effect, using two electrolytes which mix with difficulty (e.g., dilute and concentrated H_2SO_4). One of these liquids was poured on top of the other in a glass basin. The ions move perpendicularly to the plane of demarcation. If the basin is placed in a magnetic field the ions deviate and there is a rotation of the upper liquid, which can be easily observed by strewing lycopodium powder on the liquid. If the direction of the field is changed, the direction of rotation also changes. The same rotations can be created with weak electric currents (less than 10^{-3} Ampère). A rotational speed of 10 cm/sec can be measured in very strong magnetic fields (abt. 7,000-10,000 lines of force/cm²).

The same rotation occurs if a metal (e.g., lead) is placed in a solution of nitric acid and afterwards brought into a magnetic field. URBASCH used this different behaviour of ions for separating iron, nickel and cobalt by precipitation from bismuth salts in a solution. The Fe-ions precipitated near to the magnet only.

PIERUCI (Bibl. No. 243) demonstrated with magnetic fields of 20,000 Gauss that diffusion currents can be slowed down by placing the liquid in this field.

SSAWOSTIN (Bibl. No. 249) could prove the influence of the URBASCH effect on the rotational phenomena in the cytoplasm of plant cells (see p. 13 and 270).

The influence of magnetic fields on ionic movements in gases has also been studied.

TOWNSEND and TIZARD (Bibl. No. 252) demonstrated that the deviation of a stream of negative ions in gas is due to a magnetic field.

URLSON (Bibl. No. 257) studied the change in conductivity of a Bunsenflame produced by a magnetic field, the direction of which was perpendicular to the current through the flame.

The flame consisted of a row of 12 flames, each touching the flame following. Two electrodes of platinum were placed in the flame and connected with a battery of cells and a galvanometer. Sudden changes of the field created changes in resistivity of the current in the flame which were not due to direct induction in the wires connecting the electrodes with the galvanometer.

It was found that a magnetic field of 1,000 Gauss changed the resis-

tivity of the flame with 0.3%, 2,000 Gauss with 1.3%, 3,000 Gauss with 2.6%, 4,000 Gauss with 4.8%, 5,000 Gauss with 8.0%.

De Vita (Bibl. No. 256) found a greater degree of atmospheric ionization over bands of ground that coincide with zones of variations in the magnetic and electric field of the earth (see p. 257).

Electroscopes placed above these zones discharge more rapidly. As electroscopes placed near to trees, houses, water supplies, etc., also showed a more rapid drop of potential, by discharge due to ionization, than did those on open ground under similar conditions, it seems more likely that this ionization effect is created by variations in the electric potentials of the earth surface and in the potential gradients of the atmosphere (see meteorological field p. 247).

The phenomenon is also interesting as the influence of the ionic content of the inspired air on the health of living bodies seems to be of importance (see p. 259).

In 1935 Maby (Bibl. No. 238), using a neon-tube-ionization counter, repeated De Vita's experiment and in general confirmed his observations. The latter were made, day and night, over a period of several months, readings being taken every five minutes by means of an automatic recorder. Maby found, however, that no consistent difference exists between a zone of disturbance and the adjacent area. Differences of 5% may occur for short periods, but the mean statistical difference for a month of readings was only 0.214%.

A fifth important magnetic effect is the so-called *magneto-chemical effect*. Between 1915 and 1920 Stschukareff (Bibl. No. 250) discovered that certain chemical reactions take place differently, probably as a result of magnetic induction currents in moving electrolytes (treated in a constant field) or in a non-moving electrolyte by pulsating or alternating electromagnetic fields. His observation can be described as *magneto-electrolysis*.

In 1923 Pissarshewsky and Rosenberg (Bibl. No. 244) found that magnetic fields of 2,500 Gauss create a considerable increase in oxidative reactions in liquids where para-magnetic ions are involved; reactions between para- and diamagnetic ions were slowed down. On page 58 we observed that three important para-magnetic elements occur in living matter: iron, oxygen and potassium; hydrogen and water are diamagnetic; copper, important in hemocyanin of invertebrates is also diamagnetic. Mc Hargue could prove the importance of nickel and cobalt, both ferro-magnetic metals, in grass of Kentucky which help plants to synthesize.

Leiri (Bibl. No. 237) assumed that the chemical reaction between para-magnetic hematin (and hemochromogen) and oxygen is a magneto-chemical reaction influenced by external magnetic fields. Those fields should also have a directive force on the hematin bodies in the hemoglobin and erythrocytes which might influence the resistance of the moving erythrocytes in the blood plasma. The experiments of Cardin (see p. 79) are very instructive in this respect.

The last important bio-magnetic factor known at present is the *creation of induction currents.* They were measured experimentally by HERMANN, DANILEWSKY, SCHIFF, and GRANDIS (see p. 121 and 122), who could demonstrate the creation of currents in nerves through induction of a magnetic field. SSAWOSTIN (see Bibl. 249 and p. 267) could prove the existence of such weak induction currents in the cells of plants. The general importance of these weak currents is their influence on the internal distribution of electric potentials. *Slight changes might* just *alter the permeability of membranes* for ions or bacteria or *the stability of colloids.*

BEUTNER a.o. has shown that the potential of a phase boundary (see p. 17-18) can be negatived by certain drugs in dilution of 10^{-8} and less. We have discussed the "DE KRUIF-NORTHROP-*effect*" (see p. 55-56) which might cause the living conditions of pathogeneous bacteria to be slightly improved or deteriorated. We have also considered the phenomenon of *magneto-electrolysis* and the *electrolytic experiments of* GAMGEE (see p. 61) with oxyhemoglobin solutions. All these subtile physico-chemical processes, if they take place during long periods — particularly in nerve cells — are bound to have a permanent biomagnetic effect. In chapter II on p. 264-282 we discuss several experiments which support this assumption.

It is difficult to realize that these phenomena, which are observable in a relatively short time by using very strong magnetic fields (in general more than 1,000 Gauss), would have any influence if living matter were subjected to weak magnetic fields of 1 Gauss or less. In order to explain this we must return to the inorganic crystalline world and particularly to the phenomena of plastic deformation of rocks (see also p. 99: law of constancy of exitation energy).

It is known that rocks can be deformed plastically, but only under very high pressures and temperatures. It is difficult, however, to explain the plastic deformations of folded rocks on the surface of the earth, where those laboratory conditions have never existed. The studies of KÖNIGSBERGER and HUNGERER (Bibl. No. 236), SCHMIDT (Bibl. No. 248), SANDER (Bibl. No. 247), NADAI (Bibl. No. 241) and BURGERS (Bibl. No. 224) have shown that those plastic deformations in rocks are only understandable when the time factor is introduced. The author (Bibl. No. 253) pointed out that each substance and therefore also a rock, composed of different crystalline minerals, possesses two limits of elasticity: the *external* or *practical limit of elasticity* (i.e., the force required to produce at no distant date visible permanent deformations) and the *internal limit of elasticity* (i.e., the force required to create permanent deformations at one or more points in the centre of a body as a result of micro-movements along micro-sliding planes in the space-lattice structures of the crystals). This internal limit is considerably smaller than the external limit, which is the one generally measured in engineering studies. As long as the external forces exceed the internal limit of elasticity permanent deformations will occur although it might be a long period of time before the deformation is externally visible. It is a kind of catalytic process. The internal micro-movements lower the limit of elasticity in neighbouring points and as a result the limit of elasticity can be surpassed, in those points. These considerations explain the practical *law of* KÖNIGSBERGER and HUNGERER: *Small, continuously acting forces are able to deform any body if this process takes place for long periods* and as long as in certain points the internal elastic limit can be surpassed. This phenomenon is known in technics

as *fatigue of metals.* Stresses which can be applied on those bodies a few times without causing apparent structural damage may cause failure, if applied a great many times. If a polished surface of such a body is examined under a microscope minute flames will be seen to develop and spread and finally develop cracks. A similar phenomenon is known in geology. Horizontal marble tomb-stones, supported only at the ends, will say in the middle through centuries of action by gravity forces. This deformation is completely plastical.

The force required to deform a rock in a relative short time was established experimentally by ADAMS and KING (Bibl. No. 214 and 215), GRIGGS (Bibl. No. 233 and 234), BRIDGMAN (Bibl. No. 220), BIRCH and BANCROFT (Bibl. No. 217 and 218) a.o. This force varies between 20,000 and 50,000 atm/cm². A limestone of SOLNHOFEN, which requires 30,000 atm. or more to be deformed plastically in a very short time, could be so deformed by a force of only 1,400 kg/cm² if the force was applied continuously for 550 days.

If we apply this to the physico-chemical deformations in liquids and crystalline substances of the living cell (particularly the nerve cell) as a result of magnetic fields, it seems logical that these small forces, if acting continuously during long periods, could create permanent deformations in living matter, as long as the internal limit of physico-chemical elasticity can be surpassed. The ratio between an artificial magnetic field of 2,000 Gauss and 0.2 Gauss (the magnetic field of the earth) is 10^4. In view of the above-mentioned data for rocks it is logical to assume that any magneto-biological effect is only observable after long periods unless the forces applied are very large. We must nonetheless bear in mind that the deformation processes in rocks occur in solid crystals with rather strongly built space lattice structures, whereas the micellae are composed of fluid crystals with less stable structures. Experiments on bio-magnetic phenomena have shown that the force as such is not of so much importance as the gradient of the field strength (see p. 322).

The above-mentioned similarity between permanent deformations in living and inorganic matter is supported by *the phenomena of permanent magnetization in the earth magnetic field*, which indicate again the significance of the time factor. As these phenomena are at the same time of importance in the geophysical field (and particularly on dowsing) we discuss them more in detail.

Non-magnetic iron bars, stones, central heating radiators, telephone or telegraph poles, iron gates, etc., when kept for a long time in the same vertical position are gradually transformed, by the magnetic field of the earth, into magnets with a north pole at the lower end and the south pole at the top. This is due to the vertical component of the magnetic field of the earth. Horizontal iron bars, e.g., the railing of a bridge, placed in a N.S. direction, gradually obtain a south pole at the southern end and a north pole at the northern end.

Cast iron lamp posts, however, often possess a north pole at the upper end. This is due to the property of cast iron that during the melting and cooling process it receives the magnetic properties of the magnetic field of the earth and as the lamp posts in the foundary are

placed with the upper part down, this upper part is transformed into a north pole. Because of the great magnetic rigidity of cast iron the magnetic distribution cannot be changed.

It was already known in the 18th century that rock cliffs often possess a pronounced magnetic polarity. We have seen on page 75 that most rocks are more or less magnetic, due to traces of ferro-magnetic minerals, basalts and basic igneous rocks being the most ferro-magnetic. This magnetic property is bound to the upper part of the earth crust and decreases rapidly with increasing depth, probably due to the rising temperature (abt. 3° C per 100 m). Protruding rocks such as the famous granite walls in the Harz (Germany), basalt pillars in the Eifel, etc., possess a pronounced polarity with a north pole at the lower end. Part of this magnetism might be caused by lightning.

It is a well-known fact that objects in the neighbourhood of lightning become magnetic, even cast-iron objects. In mountainous regions debris of basic rocks around the place where lightning has struck, are changed along a circle into magnets with alternating south and north poles similar to the lines of force around an electric conductor. Lightning passing over a cliff often leaves a track characterized by a north magnetic development of the rock on one side of the track and a south pole on the other end. The intensity of magnetization of those rocks depends only upon the maximal intensity of the lightning current. However, the greatest part of the rock polarity is due to the magmatic origin of the rocks and the gradual magnetization in the magnetic field of the earth.

Melloni (Bibl. No. 239) and Folgheraiter (Bibl. No. 231) studied the basalt flows of the Vesuvius volcano and the Roman Campagna. They found that historic and recent flows possessed a magnetic south pole at the upper part and a north polarity at the basal part. Melloni discovered that this polarity originated during the solidification of molten basalt mass and that the more rapid the cooling the stronger was the polarity. Melloni's observations were confirmed by Brunhes and David (Bibl. No. 222).

Nish and Johnson (Bibl. No. 242) discovered magnetic polarity phenomena in non-magmatic rocks, e.g., recent sediments.

The previous examples demonstrate that small magnetic forces acting continuously for long periods can create permanent disturbances in the electronic orbits of the atoms of crystalline substances. This observation supports our previous statement that even weak magnetic forces, acting continuously for many years on the same body can create permanent bio-magnetic effects. The forces can be created artificially or be due to disturbances in the normal distribution of the lines of force of the magnetic field of the earth. The latter causes magnetic gradients which can have a biological importance if the disturbance is sufficiently large.

IC. 1. d: Sensitivity of protoplasm to homoeopathic concentrations
(see table p. 27, Bibl. No. 260-271a)

A great number of scientists have studied the problem of homoeopathic concentrations, i.e., concentrations which cannot be ascertained or determined by the most modern spectroscopic methods. The limit for a chemical analysis is at the concentration of abt. 10^{-10}; spectroscopic methods can indicate the existence of concentrations of 10^{-15}, i.e., abt. 1 gram of salt in 10^{12} litres of water. This means that in an enormous cube with sides 1 km in length only 1 g of salt is dissolved. Experiments indicate, however, that considerably smaller concentrations can be registered by living matter. As the initial studies were made by homoeopathic doctors with insufficient physico-chemical knowledge and by a group of charlatans, the majority of scientists reject any report on homoeopathic concentrations more or less on principle. This is most regrettable as a great number of studies by serious scientists indicate that a systematic scientific study of this problem might reveal a number of unknown facts of great importance to physical chemistry, biology and medical science. The problems, however, are more or less comparable to those discussed in the section on GURWITSCH-radiation (see p. 24). The great variety of organic matter and their changing sensitivity make them difficult physical instruments if constant reproducible results are to be obtained.

We mentioned on page 71, the influence of traces of organic matter on the photo-dynamic action of living matter. The following experiments indicate the great sensitivity of living matter to other physico-chemical impulses. None of these experiments are conclusive, however, as other research workers (Bibl. No. 269a, 271a) who repeated the experiments often obtained negative results similar to the experiments on the GURWITSCH effect. Still, they are very instructive as they describe several scientific methods which can be applied to this problem.

The first great number of experiments were made in the Anthroposophical laboratories at Dornach and Stuttgart by N. P. KRAWKOW, L. KOLISKO, and E. PFEIFFER. They were followed by the experiments of HINSDALE, STERN a.o. in the U.S.A., by JUNKER, KÖNIG a.o. in Germany and by W. E. BOYD and his students in Glasgow (England).

Experiments of N. P. KRAWKOW (Bibl. No. 269):

KRAWKOW studied the influence of certain chemical substances on the dilatation and narrowing of vessels in the isolated ears of rabbits. By diluting the poisonous fluid a decrease in the reactions was at first observed, but at a certain stage of attenuation the reactions became very strong again, followed by a new decrease (after further diluting), etc. Several maxima and minima could be observed till a diluting stage of 10^{-32}, after which reactions could no longer be seen.

Experiments of L. KOLISKO (Bibl. No. 266 and 267):

Mrs. KOLISKO first studied the maximum height to which a fluid rises by capillary movements. These experiments were based on studies of GOPPELSROEDER (Bibl. No. 261) and PLATZ (Bibl. No. 271). She noticed a maximum height at the diluting stages 10^{-2} and 10^{-18}, a minimum at 10^{-21}. A great height, although not a maximum, was reached at 10^{-25} and 10^{-27}.

The same was observed in the growth of plants watered by certain solutions. The maximal total length of the plant was obtained at the diluting stage 10^{-17}, the maximal development of leaves at the stage 10^{-25} and 10^{-27}, the minimum growth at 10^{-21}, the minimum weight at 10^{-20}.

KOLISKO distinguishes two phases of a solution:

Attenuation and *potency*. If 1 gram of salt is placed in 1,000 litres of water and thoroughly mixed she speaks of a stage of attenuation of 10^{-6}. If one gram of salt is diluted first in 10 ml of water and one ml of this solution then diluted 10 times again, etc., we obtain the concentration 10^{-6}; this solution, however, is called a potency and behaves differently from the diluting stage 10^{-6} (according to KOLISKO a.o.).

No positive evidence can be advanced that the distribution of salt molecules in both fluids is the same. It is easier for a physicist to accept the even distribution in his calculations.

It is quite probable that cohesive and other electric forces create an irregular distribution of salt molecules in liquids, that move through irregular channels of varying structure and texture, such as the soil, in which the roots of plants exist (see further p. 92).

Experiments of PFEIFFER (see Bibl. No. 270):

PFEIFFER demonstrated similar phenomena with crystallization phenomena of electrolytes to which traces of organic matter from living organisms (plantsaps, blood, etc.) were added. Characteristic crystallization figures could be obtained even at very low concentrations (see p. 31).

Experiments of A. E. HINSDALE (see Bibl. No. 262):

HINSDALE used isolated muscle fibres from rabbits treated with *physostigmin*, which is known for its capacity to cause a contraction of the muscles of the stomach and intestines. The physostigmin solutions were gradually diluted and the reactions on muscle fibres recorded. These experiments showed the enormous sensitivity of living tissue to physico-chemical impulses.

Experiments of W. E. BOYD (Bibl. No. 260 and 260a):

A great number of experiments have been and are still being made at the Laboratories of the BOYD Medical Research Trust in Glasgow. One of the type of experiments carried out is as follows: It is known

that mercuric chloride attenuations, by extremely delicate micro-biochemical methods, can influence the action of the enzyme diastase on starch, as compared with its gross inhibiting action in ordinary amounts. Such an activity is shown in certain attenuations up to abt. 10^{-14}.

The type of effect appeared to be caused by the electro-physical state of the attenuation rather than the quantity of drug in the solvent and is closely related to the method of preparation of a certain stage of attenuation. A certain stage of dilution might be inactive on the diastase if prepared by common attenuation, whereas a potency can inhibit the action. One of the causes of this different behaviour is explained by BOYD with the theory of monomolecular layers (see p. 18). Only a certain distribution of molecules in a solvent might create in the living body a reaction at the place of contact with monomolecular layers. Adsorption from a liquid in contact might take place in one case but not in another, depending whether or not the surface condition of the monomolecular film is suitable. This *phenomenon* of *selectivity* in living processes might be due for the most part to these particular properties of monomolecular layers. This property of selectivity of the colloidal substances in living matter is also indicated by the action of radioactive tracers such as radio-sodium, radio-phosphorus, radio-iodine, etc. Salts, temporarily transformed into radioactive isotopes and administered in the ordinary way, behave normally at very small concentrations. In other words, a physically altered radical may exert its physico-chemical action independently of the substance of which it is a part.

BOYD (Bibl. No. 338a-d) studied the changes in the infra-red radiation spectrum of human bodies caused by homoeopathic concentrations of drugs (see p. 120). In connection with the problem of photo-dynamic action of drugs (see p. 71) an extensive study of the whole problem may prove to be of great value to medical science.

Experiments of Junker (Bibl. No. 263, 264 and 265):

1. Experiments were carried out in 1925 in the colloid-biological station of EPPENDORF in Hamburg on the influence of homoeopathic concentrations on the growth of *paramecium* up to concentrations of 10^{-27}. In each of 27 carefully cleaned glass beakers of the same size, 10 ml of a feeding solution was poured (composed of 1 g of sugar, 0.2 g glycol on 800 ml of water). 1 ml of the tested chemical substance was added to the first beaker. After being mixed, 1 ml was taken out and added to the second beaker. This was repeated with the second and third beakers, etc., until finally a dilution stage of 10^{-27} was reached. The pure feeding solution was kept in glass 28 only.

From each attenuation 18 drops were placed on carefully cleaned watch glasses of 5-6 cm. diameter. To each watch glass 5 parameciums were added and the glasses kept in a damp room at constant temperature and with an average light intensity. From each potency two

cultures were prepared, which were compared with 3 controls in normal feeding solution. The increase in the number of parameciums was counted each day with the aid of a magnifying-glass. Experiments carried out with orange juice, lemon-juice, caffeine and atropinum sulfuricum, etc., gave the following results:

Atropinum: minimum growth at potencies of 10^{-5}, 10^{-12}, 10^{-24}, maximum at 10^{-8}, 10^{-19} and 10^{-26}.

Caffeine: minimum growth at potencies of 10^{-6}, 10^{-12} —10^{-13}, 10^{-24}, maximum at 10^{-4}, 10^{-7}, 10^{-19} and 10^{-22}.

Lemon juice: minimum growth at potencies of 10^{-7} and 10^{-15}, the curve as a whole subsiding with increased diluting.

Orange juice: several smaller minima, but only one pronounced minimum at 10^{-13}.

The fluctuations between maximum and minimum development amounted to abt. 12 parameciums (on the 6th day with atropin and on the 8th day with caffeine).

2. In 1928 JUNKER repeated his experiments with parameciums and found the same minimum and maximum developments. They seem to occur at certain concentration intervals which are rather independent of the kind of poison used. In order to study this phenomenon more extensively experiments were carried out with *yeast of beer*. The method used and all the precautions taken are fully described in Bibl. No. 265, page 365. The number of yeast cells were counted every 24 hours.

With *atropinesulphate:* a minimum increase was obtained at a concentration of 10^{-5}, at 10^{-12} and at 10^{-24}—10^{-25}.

With *potassium salts of oleic acid:* a minimum occurred at 10^{-5}, 10^{-13} and 10^{-24}.

Similar experiments with caffeine, gallic acid, octylalcohol, nonylic acid, copper sulphate, lemon juice, apple juice, etc., gave the same results. The characteristic growth curve appeared only after abt. 4 days. Although slight fluctuations occurred in the specific concentration, e.g., 10^{-13} instead of 10^{-12} or 10^{-24} instead of 10^{-25}, the general picture suggested that apart from the curve pictures, which were characteristic of a certain chemical substance, rather specific concentrations with minimum development occurred, which seemed to be independent of the stimulating substance.

JUNKER pointed out that unless the greatest care is exercized, experiments may yield negative results, as disturbing factors can easily dominate the influence of the potencies. This might explain the contradictory reports of LUDWIG and SEYBOLD (see Bibl. No. 269a and 271a).

3. JUNKER also studied the influence of homoeopathic concentrations on the development of *mycelium* (i.e., cell bodies of fungi containing fibres, the so-called hyphes) out of exogeneous spores, the conidians (by asexual reproduction), of the toad-stool *Monilia candida* (belonging to the Discomycetales), which was cultivated on grape sugar agar (see

Bibl. No. 265, p. 474). Experiments were carried out with atropine sulphate, caffeine, potassium salt of oleic acid and lemon juice. With *atropine sulphate* the mycelium curve showed a minimum at a concentration of 10^{-6}, 10^{-15} and 10^{-24}.

With *lemon juice* an irregular curve was obtained with a minimum at 10^{-11}, 10^{-15} and 10^{-23}.

Experiments of SEYBOLD (Bibl. No. 271a):

SEYBOLD based his experiments on the publications of NAEGELI (Bibl. No. 269b) who, about 1893, studied the influence of small quantities of poison on living matter. This influence was described by NAEGELI as *oligodynamic activity* and was observable up to concentrations of 10^{-42}. Later studies by NAEGELI revealed that this high value was incorrect and was due to the type of basins used; the latter absorbed some of the poison which was released during later experiments. The actual limit of oligodynamic activity would be only 10^{-6} according to NAEGELI.

SEYBOLD studied the influence of methyl violet on zoospores of *Plasmopora viticola*. As indicator, the "average time of mortality" was used, i.e., the time required to remove the mobility of at least half the organisms (which mostly was followed rapidly by complete death). The following results were obtained:

Potency	Average time of mortality
10^{-3}	0 minutes
10^{-4}	0 — ½ ,,
10^{-5}	1 — 2 ,,
10^{-6}	2 — 3 ,,
10^{-7}	8 —12 ,,
10^{-8}	70—80 ,,
10^{-10}	100 ,,
10^{-14}	480 ,,
10^{-16}	24 hours ,,
10^{-17} and less	24 hours no reaction, then gradually germinating.

With copper sulphate the limit of oligodynamic activity lies at 10^{-8} (after 3 hours).

SEYBOLD, in contrast to JUNKER, a.o., did not observe any secondary minimum or maximum developments.

JUNKER makes no attempt to explain the oligodynamic phenomena. He suggests only the possibility that the specific biological effect of certain potencies might not be due to the molecules but to the fragments of molecules which originated during ionization, i.e., ions (of the original molecule and dissociated parts) and electrons.

It is well known that recent studies have revealed several ambiguities in the original ionization theory of SVANTE ARRHENIUS. It must be borne in mind, for example, that ionization is not restricted to solutions

of electrolytes in water. Many other solvents, e.g., ethylalcohol and other organic substances, can be used.

An 0.5 n. solution of HCl at 18°C is dissociated for 85% only, at 0.1 n. 92%, at 0.01 n. 97%. At very high dilutions the ionization becomes practically complete. This means that of a gram molecular weight of hydrogen chloride at very high dilution $6.06 \cdot 10^{23}$ hydrogen ions and chloride ions must be present. In more complicated substances due to secondary dissociations this change in ionization, measured by the degree of conductivity, is less regular and maxima and minima may occur (see also p. 65, action of HERTZIAN waves). One of the causes is that acids and bases show the most extreme differences in their degree of ionization and therefore exhibit very marked differences in chemical activity. Water itself breaks up in H and OH ions; at normal temperature less than $2 \cdot 10^{-9}$% is ionized. Whether this percentage changes, due to the presence of other atoms, is not yet known with certainty. One of the causes would be local changes in temperature due to chemical reactions between certain atoms. With weak electrolytes the fraction ionized frequently increases to a maximum and decreases with further rise of temperature. The weaker the electrolyte the higher the optimum. Water also gives rapidly increasing values if the temperature increases. If ions with great chemical affinity were to meet in solution the chemical reaction might be exothermic and a great amount of heat released (e.g.; oxidative reactions). On page 44 we give a list of the order of activity of metals (the first one displacing hydrogen from water so violently that the gas ignites), which represents the relative tendencies of metals to lose electrons. Though local heating at certain points of a solution might not be observable externally, it might still exist internally. This creates locally a greater dissociation of the water molecules. These local chemical reactions are not only determined by the amount of contact between existing ions in a solvent; because of the presence of living matter, chemical substances are secreted in water which, through diffusion, might reach certain ions of the original solute, thus creating the local exothermic reactions.

On page 66 we mention the observation of FRICKE, HART and SMITH, that the action of radiations on dilute aqueous solutions is mainly due to the ionization of the solvent molecules. To convert a water molecule into H and OH radicals only 5 eV is required, the OH radicals being highly reactive as electron-acceptors.

We have seen that irradiated diluted solutions can inactivate enzymes by the action of H and OH radicals and that the amount of radiation energy required to produce a chemical change in a substance by direct action is inversely proportional to its molecular weight. These and similar considerations (p. 66) might give a clue to the problem of homoeopathic concentrations.

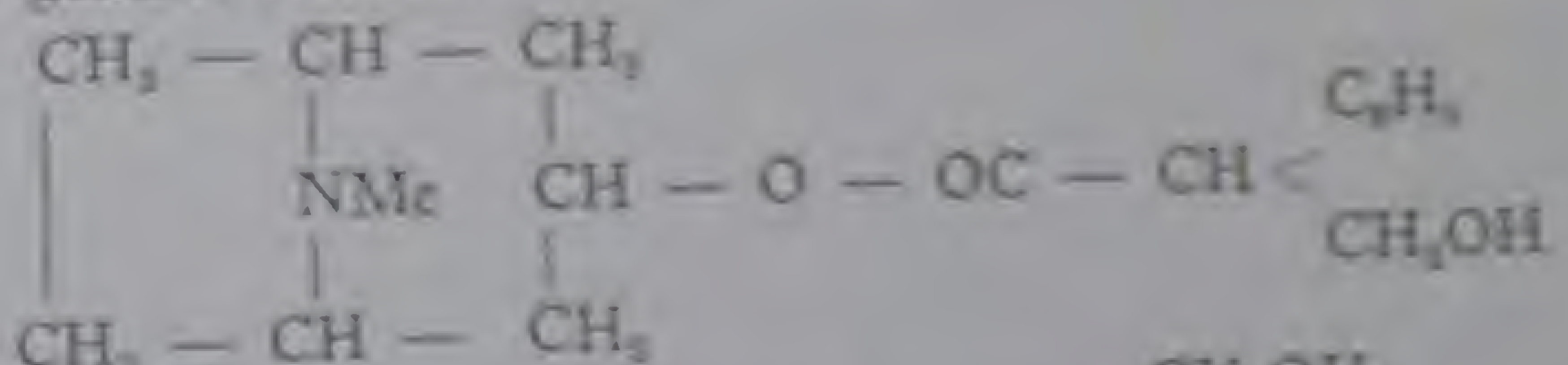
In this connection we have to point out the relative value of the *law of molecular concentration* of GULDBERG and WAAGE (1864), i.e., in any given chemical change

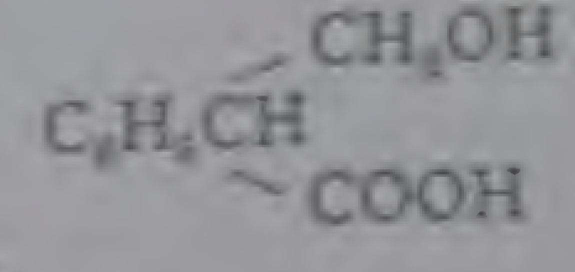
the apparent activity, and therefore the speed of action, is proportional to the molecular concentration of each interacting substance. This law can only be applied to a chemical system in which the attractive forces between the various reacting molecular species are not appreciable. When the proximity of ions (e.g., in solutions with large concentrations of ions) or external directive electric fields impose electric forces on certain ions, the effect on the chemical reactions is considerable. The environment of those ions will not be the inert environment postulated by strict kinetic-molecular theory for the applicability of the law of mass action; as a result the apparent concentration of activity of ions will by no means be identical to their true concentration in the solution.

All biological processes in living matter are closely related to electric fields. The presence of diluted solutions in the neighbourhood of living matter therefore excludes the full applicability of the law of molecular concentration.

In 1908 A. A. NOYES referred to the possibility that the so-called undissociated fraction of a salt in a solution might exist in a *potentially ionized* condition. This theory is supported by the work of BRAGG on the crystal-structure of NaCl, which indicated that not salt molecules were present in the crystal space lattice but an alternation of sodium and chlorine ions. This idea formed the basis of the *theory of complete ionization of* DEBYE *and* HÜCKEL (1923) who demonstrated mathematically that departures of complete dissociation in dilute solutions is entirely due to electric forces between the ions. This theory confirms the *empiric law of* KOHLRAUSCH: for any given electrolyte the apparent fraction "un-ionized" varies as the square root of the concentration. It is therefore not the degree of ionization that changes considerably at different concentrations but the mobility of ions.

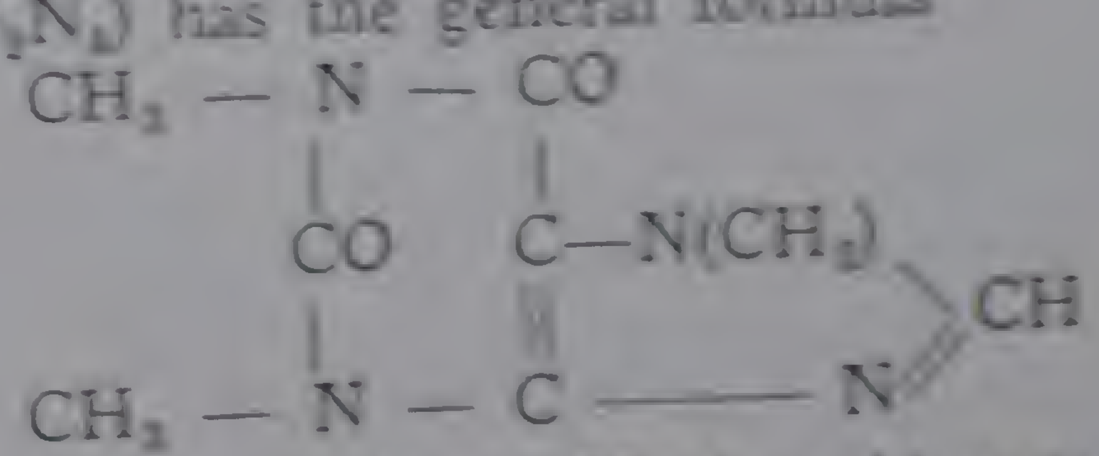
Atropinum sulfuricum has the formula $(C_{17}H_{23}O_3N)_2H_2SO_4$ and is soluble in water. It readily dissociates in H_2SO_4 and *atropine* $(C_{17}H_{23}O_3N)$, with the general formula:



Atropine hydrolyses with water into 

(*di-tropic acid*) and $C_8H_{15}ON$ (*tropine*)
Tropine with acids gives *tropidine* $(C_8H_{13}N)$; if oxidized *tropinone* $(C_8H_{13}ON)$ originates.

Caffeine $(C_8H_{10}O_2N_4)$ has the general formula



It is a feeble base, sparingly soluble in cold water. With strong acids it forms salts.

In case of lemon juice and orange juice an even more complex mixture of organic compounds is present, the degree of dissociation being determined by the solvent, the solutes (glycol, sugar) and the presence of living matter, creating electric fields and local exothermic reactions. These considerations indicate sufficiently that dissociation of complex organic compounds in the presence of living matter creates a considerably greater number of physico-chemically active components (ions and electrons) than is generally assumed (i.e., considerably more than 10^{23} per gram-molecule). SEYBOLD (Bibl. No. 271a), for example, calculated the number of molecules present in a concentration of 10^{-20} of $CuSO_4$ at abt. 4000; at a concentration of 10^{-23} it is only 4. The maximal number of electrons of these 4 molecules is $4 \times 77 = 308$, which leaves at a concentration of 10^{-26} only 0.3 electrons.

In the case of adrenalin ($C_9H_{13}O_3N$) the number of molecules at a concentration of 10^{-20} is 80000, at 10^{-24} only 8, the number of electrons being max. $8 \times 98 = 784$, i.e., at a concentration of 10^{-26} only 7.8 electrons. SEYBOLD therefore concluded that at concentrations of 10^{-30} electronic chemical acticity must be excluded. In the case of atropine at a concentration of 10^{-24} max $8 \times 156 = 1{,}248$ electrons can be expected on the basis of SEYBOLD's calculation, i.e., 1.2 electrons at 10^{-27}. It is evident from the previous considerations that such a simplistic analysis is quite incorrect.

The phenomenon of alternately increased and decreased growing speed (yeast) or mobility (paramecium) might be related to the phenomenon of *physico-chemical periodicity* (Bibl. No. 137-147, p. 49).

Many of the processes of ionization in solutions are still unknown, but it is evident that a careful analysis of these phenomena is of importance to physical chemistry and medical and biological sciences of the future.

IC. 1. e: Sensitivity of solutions and colloids to meteorological and cosmic influences (see table p. 27, Bibl. No. 272-281)

The influence of meteorological or cosmic forces on living matter can be direct or indirect (through changes in the physico-chemical conditions of the medium surrounding living organisms). It is well known that sudden variations in the structure of the *Heaviside layer* of the atmosphere occur (see meteorological field, p. 243) during periods of sun spots or eclipses of the sun as a result of changes in the stream of ionizing corpuscular rays from the sun. These changes of the Heaviside layer show up as disturbances in radio reception and "northern lights". Abnormal weather conditions on earth might be caused by such periods of cosmic disturbances. They are accompanied by fundamental *changes in the electric field of the atmosphere* (see p. 250), the *magnetic field of the earth*, changes in *atmospheric radiation phenomena* etc.

Cosmic influences can show up also as *changes in gravity*, the most striking example being the tidal movements which, according to NOUVEL (Bibl. No. 280) and WHEELER (Bibl. No. 281), are responsible for the periodic moulting phenomena of crustacea. Sexual and regeneration phenomena of these animals seem to coincide with lunar periods.

Changes in the electric field of the atmosphere (acting directly on living matter, see p. 254-258 and 122, or indirectly through the inspired air in the lungs, see p. 260), in the magnetic field of the earth, in the atmospheric radiation or in the gravity conditions on earth might influence the physico-chemical condition of the protoplasm of the cell (determined by its viscosity, electric charge crystallization forces, symmetry, etc.), the mitogenetic radiation (which seems to influence the cell division phenomena), the kind of chromosomes which disappear during the reductional division of the oogonia and spermatogonia, the structure of the genes, the final association after sexual reproduction, the angle between cleavage plane and planes of symmetry during reproductional division and other fundamental processes that determine the properties of the future organism.

The influence of cosmic *phenomena* has been studied by several scientists in different ways:

ALVAREZ (Bibl. No. 273) Doctor at the School of Tropical Medicine in Puerto Rico, in 1932 compared the fluctuations in sun spots, magnetic field of the earth and ultra-violet radiation with diastolic pressure and total count of leucocytes of 43 persons. Altogether 4,560 pressure measurements and 808 leucocyte counts were made. According to ALVAREZ the 5 curves were more or less parallel.

BURR (Bibl. No. 273a and 273b), Prof. of Neuroanatomy at the Yale University School of Medicine (U.S.A.), discovered that the diurnal variations in the growing speed of trees (originally found by D. T. MAC DOUGAL in 1921) was reflected by diurnal variations in the electric surface potentials of the trees, which were measured with vacuum tube micro-voltmeters (see p. 197). These surface potentials had no correlations with changes in barometric pressure, temperature or humidity during the same period. BURR assumed a possible relationship between tidal forces created by the moon in the saps of the trees and variations in the standing electric potentials.

KOLISKO (Bibl. No. 274-279) used capillarity experiments for demonstrating cosmic influences on living matter. The experiments were carried out between 1926 and 1933 in the Biological Institute of the Goetheanum in Stuttgart, Germany, one of the scientific institutes of the Anthroposophists, under leadership of Dr R. STEINER. KOLISKO first studied the growing curves of different wheat species in relation to the phases of the moon. Hungarian wheat, growing either in the open air or in a dark room, showed the same rhythmic variations in growing speed in relation to the phases of the moon. Oats and barley showed similar curves.

In July 1927, during a conjunction of the planet Saturn with the moon (i.e., the moon and Saturn on the same line with the earth, but on both sides) capillarity experiments were carried out with different salt solutions.

A mixture of equal quantities of 1% solutions of silver nitrate, ferro-sulphate and lead nitrate showed pronounced capillarity figures (see also Bibl. No. 261 and 271) after the rising of these solutions in filter paper for 10 minutes. The experiment was repeated before during and after the conjunction. During the conjunction the remarkable capillarity figures disappeared. The most striking observation of KOLISKO was that a solution of silver nitrate and ferro-sulphate, without lead nitrate, did not show any cosmic influences during the same conjunction. Similar experiments were repeated in February 1934, with a mixture of 1% solutions of silver nitrate and ferro-sulphate (without lead nitrate) during an opposition of Mars and the moon (i.e., both on the same line with the earth and on the same side).

In these circumstances the capillarity figures disappeared during the opposition, in contrast to the previous experiment.

In June 1927, the influence of a total eclipse of the sun on gold solutions was observed and described by KOLISKO.

It is evident that these experiments of KOLISKO need to be repeated for many years before his observations can be accepted. However, if they prove to be correct we must assume similar processes in the living body with its complex capillarity phenomena.

PFEIFFER (Bibl. No. 270) used the sensitivity of crystallizing solutions to register cosmic influences. According to PFEIFFER, a characteristic crystallization figure of Glauber's salt, prepared in the afternoon, changes during the night, although it had been prepared under similar conditions of temperature, etc. The picture changed completely during an eclipse of the sun. The experiments were made with a saturated Glauber's salt solution prepared at 34°C, crystallization taking place at 18-20°C in abt. 20 minutes (see also p. 31).

These observations must be carefully tested before we can be convinced that they are not due to non-cosmic forces.

If PFEIFFER's observations prove to be correct it is logical to assume similar influences on the micella crystals in the cell protoplasm.

MC.ADIE (Bibl. No. 272) showed the influence of considerable electric charges in the atmosphere on liquids. If an insulated water dropper collector is used and a stream of water leaves the nozzle, it will split up gradually below the nozzle into separate drops of water. If this collector is used during a thunderstorm (just before a flash of lightning), the stream, under the influence of the increasing electrification, twists and splits into threads and spray until the very instant the flash occurs, when it resumes again its normal character. The same can be demonstrated by bringing the pure stream of water (abt. 4-5 inches away) near to an

insulated, highly charged brass plate. Droplets of water condense on the brass plate.

I C. 2. b: *Sensitivity of gas solutions to atmospheric pressure* (see table p. 27)

We discussed on page 44, the phenomenon of occlusion in metals. We mentioned also the development of gases in blood if an electric current of 3-5 mA is applied over a long period (exp. of GAMGEE, see p. 61). Blood contains a great amount of occluded oxygen, carbon dioxide, nitrogen, etc. (see p. 77). A sudden drop in atmospheric pressure causes a release of gases which creates bubbles in the bloodstream; this can be very dangerous if narrow capillaries in the brains are reached (*air embolism*).

So far we have considered only the sensitivity of the separate main components of the cell to physico-chemical influences. *We now review briefly the sensitivity of the total structure of the combined cell-components to physico-chemical influences.*

II A. 1: *Tropisms:* (see table p. 28, Bibl. No. 281a-294)

The different movements of plants can be classified as follows:

I. *Locomotor movements:* i.e., movements of the plant as a whole (e.g., movements of bacteria).
   - A. TOPIC TAXIS: directive movements of the axis of organisms parallel to the direction of the exciting force and linear movements towards or away from the exciting force.
   - B. PHOBIS TAXIS: movements of organisms not in the direction of the exciting force.
   - C. PHOTOTAXIS: movements due to one-sided irradiation.
   - D. CHEMOTAXIS: movements due to differences in concentration in a solution.
   - E. AEROTAXIS: chemotaxis created by oxygen.
   - F. HYDROTAXIS: movements caused by differences in humidity of the air (e.g., movements of plasmodia).
   - G. THERMOTAXIS: caused by irregular distribution of heat.
   - H. GALVANOTAXIS: caused by galvanic currents.
   - I. RHEOTAXIS: due to water currents.
   - J. GEOTAXIS: due to gravity.

II. *Bending movements:* Bending of certain parts of plants, caused byunequal increase in length of one side of an organ or unequal shortening, as a result of growth (growth movements or nutations), changes in turgor pressure (turgescence or variation movements) or fluctuations in the water content of membranes or the cell interior (hygroscopic movements).

A. Hygroscopic movements:
   1. *Movements due to swelling:* as a result of change in the water content of the cell membrane.
   2. *Cohesive movements:* as a result of reduced inner volume of the cell caused by loss of water.

B. Bending movements sensu stricto:
   1. *Autonomous movements:* i.e., movements of an ordinary living plant without specific external excitation (e.g., linear growth of roots, etc.).
   2. *Induced movements, excitation movements* or *paratonic movements:* movements caused by specific external excitation, the latter determining the rate of bending and/or direction of movement.

      a. *Directional movements* or *tropisms:*

         1. Phototropism, heliotropism or herzotropism: bending towards a light source, caused by one sided excitation.
         2. Geotropism: due to gravity forces.
         3. Chemotropism: caused by unequal distribution of chemical substances in solutions, of water vapours (hydrotropism) or other gases (aerotropism) in the neighbourhood of the plants.
         4. Traumatotropism: caused by one-sided damaging effects (e.g., cut with a knife).
         5. Haptotropism or thigmotropism: caused by one-sided frictional contact with solid substances.
         6. Thermotropism: caused by one-sided heating.
         7. Galvanotropism: caused by electric stimulation.
         8. Radiotropism: caused by radioactive radiation.
         9. Magnetotropism: caused by magnetic fields.
         10. Autotropism: caused by the tendency of plants to stretch the curved parts after the exciting external force ceases to exist.

      b. *Nastic movements:* i.e., movements caused by diffuse (not-directed) exciting forces or directed forces; the bending movement, however, is not related to the direction of the force.
         1. Thermonastics: caused by changes in temperature.
         2. Photonastics: due to light.
         3. Nyktinastics: due to both light and temperature changes.
         4. Chemonastics: caused by chemical excitation.
         5. Seismonastics: caused by excitation as a result of mechanical shock, collision, etc.
         6. Traumatonastics: caused by mechanical or chemical damage.

7. Magnetonastics: due to magnetic fields.
8. Electronastics: due to electro-static fields (see chapter II).

A few brief remarks on these phenomena might be helpful in a study of the problems discussed in chapters II and III.

Locomotor movements:

1. Cells of Vallisneria in water show no rotational movements in the cytoplasm. However, traces of amino-acids (1 mg in 30—80 l water) create those movements. This means that the presence of 10^{-11} mg of amino-acid in the cell can cause rotation of the cytoplasm.

2. Light waves with an intensity of only 22.2 Lux for 80 seconds in a dark room create plasmatic movements in Vallisneria cells. Even 0.5 Lux after a long period can do the same. The arrangement of chloroplasts in the plant cell, which allows maximal absorbtion of light, is regulated by these very weak light waves.

3. Volvocales of algae in a glass of water concentrate immediately on the side of greatest light intensity (positive phototaxis). In direct sunlight, however, the reaction is reversed, with Volvocales moving towards the shadow side (negative phototaxis).

4. Concentrations of 10^{-5} of apple-acid create chemotaxis. Fern-spermiums, irregularly distributed in water, immediately move towards the part of the solution with apple-acid molecules.

Induced movements:

1. *Phototropism* is caused by a difference in growing speed of the parts of a plant nearest to the light source and those on the opposite side. Both positive (movements towards the light source) and negative phototropic movements occur. They vary with the wavelength, light intensity and internal conditions of the plant cell.

In order to excite a plant a certain threshold value must be reached. If a plant is excited with different light waves, which are not individually able to excite, and the intervals between the excitation periods are very short, a phototropic reaction occurs (*law of accumulating stimuli*). If the intervals are chosen correctly the reaction will be equal to a continuous excitation by light waves with an energy equal to the total of the separate impulses (*law of* TALBOT). At a certain interval between the separate light impulses the reaction can be even stronger in the case of separate impulses.

In the case of two or more light sources the direction of the movement is determined by the resultant of the vectors composed of direction and intensity of the light beams (*law of resultants*).

2. *Experiments of* KNIGHT (1806) demonstrated that the direction

of growth is influenced both by gravity and by artificially created centrifugal forces.

Certain plants grow parallel to the direction of the gravity forces, *orthogeotropism* (positive, i.e., downwards, or negative, i.e., upwards) or under a certain angle *plagiogeotropism*.

If the plant grows horizontally it is called *transversal* or *diageotropism*. Orthotropism is characteristic of the root and stem of a tree, the other tropisms occurring with the branches.

Similar to phototropic movements, a certain period is required before the first influence of the exciting force can be observed. Horizontally placed germs of oats react on gravity forces after abt. 32 minutes, and in certain instances even after 14 minutes.

The *law of constancy of excitation energy* is valid for photo- and geotropism i.e., the product between intensity and time of irradiation (or gravity action) required to create a reaction is constant. Excitation with artificial centrifugal forces is therefore the same for centrifugal forces of 1 g for 300 seconds or $^1/_{10}$ g for 3000 sec; the *constant of geotropic excitation* is abt. 300 g/sec; the *constant of phototropic excitation* is abt. 25 Hefner-candle/sec.

A maximal effect of gravitational and centrifugal forces is only obtained if the forces are perpendicular to the geotropic acting organ of the plant; this indicates that the cell components that create the geotropic effect are perpendicular to the geotropic plant organs.

The law of accumulating stimuli and the law of TALBOT can be applied to geotropic phenomena.

3. *Haptotropism* is common with tendril plants, such as bryonia or passiflora; the movements of climber plants such as the ivy or bindweed is mainly geotropic.

One-sided frictional contact with solid substance creates an increase in growing speed, being greatest opposite the place of contact. As a result the part of the plant near the place of contact becomes concave. This process takes place only as a result of frictional contact. Heavy rainfall cannot initiate haptotropism, whereas a slight touch with a cotton wool fibre of only 0.00025 mg can create this phenomenon.

Whereas tendril plants can grow around any support, climber plants need vertical supports because of their geotropic sensitivity.

4. *Radiotropism* was studied by KILIAN (Bibl. No. 285) with six-day-old germs of Pharbitis hispida, subjected to the action of radium emanation. The plants were surrounded with black paper to prevent phototropism and were irradiated at a distance of 2 cm.

Radiotropism is composed of two phases: a positive tropism occurs (the germ is curved towards the emanating source) which is then followed by a negative phase. The positive phase is not very pronounced and lasts only for a short period; the curvature during the negative phase is more pronounced and lasts longer.

Where there is weak radioactive action the negative phase might change again into a positive radiotropism.

KILIAN found that the curvature is inversely proportionate to the intensity of the radioactive substance; in other words the stronger the radiation the smaller the curvature. He could prove also, by using radioactive filters, that radiotropism is mainly due to the γ radiation.

5. *Thermonastics* is the phenomenon of the opening of flowers (tulip, crocus, etc.), caused by an increase in temperature, which creates a sudden and a temporary increase in the growing speed of the flower; this is maximal at the inner side and causes an inward curvature and opening of the flower. Decrease in temperature reverses the process. Crocus reacts to changes in temperature of 0.5°C, tulip 2-3°C. Similar phenomena are known of leaves of trees which change to position during change in temperature.

6. *Photonastics* is a similar phenomenon due to light waves. Increasing light intensity opens the flower, a decrease closes them. Examples are cactus flowers, flowers of composites, etc. Night-flowering plants show the reverse, they open during the night and close when the light intensity increases (Victoria regia, Nicotiana sp., etc.).

7. *Nyktinastics* is the combined action of light and temperature. If plants have been subject to nastic movements for a long period, as a result of regular changing light and temperature condition, they will continue these periodical movements for several days if kept in the dark. Nyktinastics is mainly caused by changes in growing speed, but turgor variations are also responsible for it.

8. *Chemonastics* is common with insect-eating plants. Traces of proteins or phosphate (e.g., 0.0004 mg of ammonium phosphate) create an excitation followed by curvature and closing of the leaves. Certain tendril plants curve as a result of traces of ether, chloroform or ammonia vapour.

9. *Seismonastic* movements occur, not after frictional contact with solids, but after collision or a shock, e.g., raindrops could release this phenomenon. A well-known example of seismonastics is mimosa pudica. The phenomenon is caused by changes in turgor pressure, a decrease in membrane pressure creating a concave structure of the cell wall.

10. *Traumatonastics* is created by mechanical damage or heating. The excitation is conducted to other parts of the plants and creates the movements of the leaves. It has been found that this stimulus can be propagated over a distance of 50 cm with a speed of 1-2 m/sec and is partly caused by movements of chemical substances resembling the hormones. Concentrations of 10^{-8}, artificially applied, can create similar traumatonastic movements.

11. *Magnetonastics* was discovered by SSAWOSTIN (Bibl. No. 292) in 1931. His experiments are discussed in chapter II, page 269. Experiments with the germs of oats 40-60 mm in length, placed in a thermostatic box, showed an increase in growing speed after 11-13 minutes,

after application of magnetic fields of 200-2,150 Gauss, if the lines of force were perpendicular to the leaves. For further details see p. 268.

This short summary of the different movements of plants, caused by external forces, is required for the better understanding of chapter II. It gives also valuable information on the phenomena in the animal world.

II B. 1: *Sensitivity of animals and man to chemical excitation* (see table p. 28, Bibl. No. 295-316)

We discussed on page 32-54 the sensitivity of colloidal substances to volatile matter. This sensitivity is also revealed by the senses of smell and taste of animals and man. As many of the para-normal phenomena of man, which belong to the divining phenomena, might be created partly or completely by an extraordinary sense of smell it is useful to review the main results of recent psychological tests with animals, particularly dogs.

Man, contrary to dogs, is a *visual creature* (see Bibl. No. 296, p. 9). He acts mainly on visual impressions. A dog is mainly a *smelling creature*. His auditory sense is greater than that of man, but his visual sense is smaller, although still quite good.

The great sense of smell in a dog is the result of its large nasal cavity, which is covered with a strongly-folded mucous membrane. The most interior nasal part of this membrane, the *regio olfactoria*, contains the smell-epithelium with cells for smelling, the *olfactory cells* and the peripheral parts of the smell-nerve, the *nervus olfactorius*, which starts at the lower part of the frontal lobus of the cerebrum (see page 131). They are the actual components of the sense of smell. This epithelium with dogs is abt. 0.1 mm thick, with man 0.006 mm. The smell zone in the brain of the dog (see p. 132) is larger and stronger developed than in man.

The physical factors on which the sense of smell is based can be summarized as follows:

1. *A sufficient mass* of volatile components must come in contact with the olfactory receptors before excitation occurs;
2. the air with these volatile odours, etc., must impinge on the olfactory membrane with a *certain degree of force*; in other words when the breath is held, i.e., without inspiration, there is no olfactory perception;
3. the identification of different odours depends also on the number and structure of sensory receptors of the *trigeminal nerve*, i.e., the thickest brain nerve which starts between the cerebellum and bridge of Varol (see p. 132) and is connected with the thalamus, the great sensory ganglion of the brain stem (see p. 131); some odours affect only the olfactory cells and nerves, but many stimulate the trigeminal nerve endings; this gives a stinging, burning, hot or cool sensation.
4. odours often cannot be perceived or identified unless they are

inhaled; e.g., ether, ethylchloride or other highly volatile substances cannot be perceived unless they are inhaled.

The cense of smell is probably a combined physico-chemical and physical process; the olfactory cells are the chemical and physical receptors and the stimuli are based upon combined effects of molecular activities and of the force with which the odour particles or molecules impinge on the lipoid fluid coating the olfactory cells.

Recent studies have revealed that similar odorous substances possess the same RAMAN *spectrum*[1], which is rather constant for each substance. It was found for example that in aldehydes and ketons the changes in wavelength are abt. 1,700 A. In general the differences, due to the RAMAN effect, are abt. 1,400-3,300 Å. It has been assumed that similar smelling substances contain molecular groups which, compared with olfactory cells, have similar vibrations.
The olfactory nerve is stimulated after this resonance effect is obtained.

Studies by KÖCKEMANN (1934), FRÖSCHEL (1939), EVENARI (1940) a.o. have revealed that the growing and checking agents in plants have structures that enable them to replace one another rather easily, depending on certain physico-chemical conditions. It is interesting that the most effective checking agents proved to be the strongest odorous substances of plants.

The odorous substances reach the olfactory cells through diffusion; hence there is a delay in the perception of an odour. Inspiration causes convection currents in the nasal chamber and more rapid diffusion.

The minimum number of cubic centimetres of an odour that can be identified at once when injected into both nostrils is called *olfactory coefficient*. There seems to be a direct relation between olfactory coefficient and boiling point; the coefficient of man for turpentine is 10.7, for camphor 14.9, their boiling points being 158°C and 220°C respectively. It has been found that even 10^{-8} mg of trichlorphenol (i.e., $3 \cdot 10^{10}$ molecules) can be smelt by man after only one inhalation.

A continuous stream of air laden with a certain odorous substance creates *olfactory fatigue* for this particular substance, but the ability to recognize other odours might be preserved, which indicates that the ense of smell as a whole is not tired.

The above, mentioned phenomena could explain the extraordinary sense of smell in certain dogs, and which makes the dog live in a world of odours. Similar to the visual memories and perceptions of man, the dog has odour-memories and odour perceptions. This explains the artificial odour-dreams created in dogs (experiments of PIÉRON and ERHARD, see Bibl. No. 313), e.g., by bringing fir needles near to the nose of a sleeping hunting dog.

The most important phenomena of the sense of smell in dogs can be summarized as follows:

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[1] The RAMAN effect (see p. 30) shows up if homogeneous light waves pass through a liquid. Part of those waves are transformed into waves with smaller or greater wavelength, creating a spectrum with different lines. This RAMAN *effect* originates if electromagnetic light waves strike atoms or molecules and their wavelength does not correspond with the one required for bringing an electron on a higher energetic level. The light waves are not absorbed in this case but dispersed, part of the energy being used for increased rotation and vibration of the molecules.

1. Experiments by KALISCHER (Bibl. No. 306) demonstrated that a dog can differentiate between certain odours, which a man is unable to do; e.g., iso-valeric acid (a fatty acid probable occurring in the aroma of a human being) can be distinguished in a mixture with other fatty acids.

2. Experiment of BUYTENDIJK (Bibl. No. 298) indicated that a dog can smell iodoform in concentrations of 10^{-6}. Quinine and ordinary salt ($NaCl$), scentless to man, can be smelt by dogs, even in concentrations of 10^{-4}.

3. Experiments of HEITZENROEDER (Bibl. No. 303) and SEFFRIN (bibl. No. 316) indicated that under normal conditions dogs are not very sensitive to odours of flowers, but exceed the sensitivity of man in the case of animal odours (smell of meat, etc.). Later experiments of HENNING (Bibl. No. 304), however, showed that this is only the result of lack of canine interest in the scent of flowers. After a previous training it was found that dogs and man are about equally sensitive to vegetable odours.

4. a. A similar example of specific sensitivity is indicated by the experiments of ROMANES (see Bibl. No. 314). His dog was able to follow his track, although his shoes were greased with oil of anise and 12 people had walked one after the other exactly on the same track before the experiment started. Tracks of a stranger could not be followed.

b. If ROMANES walked in his socks (even when used many times), the dog was not able to follow his track.

c. If he walked barefooted he was able to follow the track but very slowly and with great difficulty.

d. The dog could not follow the tracks made by new boots.

e. If his old shoes were put on by another person the dog would follow the track of the stranger but not that of his master.

f. If the sole and sides of the shoes were covered with brown paper the tracks could not be followed unless a small piece of the paper was torn off (a few sq mm were sufficient). A dog therefore does not simply follow the visual impression of his master's track. This can be confirmed by the following: the experiment shown under para 4d; the experiment with trained dogs, who could not follow the well-pronounced tracks of their master, because the tracks were too old and the smell had gone; the fact that a dog does not follow the centre of a track but the boundary (the difference in smell with non-touched soil being greatest); the observation that in case of a side-wind blowing the dog does not follow the tracks themselves but a line parallel to them under the wind; the fact that dogs keep their nose higher with fresh than with old tracks.

g. The same experiments repeated with a stranger were all negative. This result together with exp. 3, indicates that *a coordination between*

olfactory excitation and brain action is required and that the general mental condition is of importance for the recognition of a certain odour.

5a. Experiments made by MOST (Bibl. No. 309-311) in 1912 in Germany with police dogs indicated that if one track was crossed by another, the dogs were general unable to follow the correct one. The artificial crossing tracks proved to be particularly misleading.

b. A dog can follow the tracks of a person of stilts. If, however, that person moves 60 cm above the ground, sitting on a board and carried along by a cable, the route followed could not be traced. This experiment of MOST indicated that a human body does not discard odorous substances as was first assumed in case of the stilts.

c. A large wheel with wooden or porcelain shoes attached to it was moved along the ground, giving the impression of human tracks but without the human odour. If these tracks crossed real human tracks or were placed in their continuation, the dogs automatically continued along the artificial tracks. These different experiments indicate that *the olfactory excitation is caused not only by a specific human odour of shoes, but probably also by the odour of crushed plants, by the smell of burrowed moist soil, soil bacteria and other organisms, the smell of leather, shoe-polishing substances, remnants of substances* in which the owner of the shoes had previously trampled, etc. Only after long training was it possible to train dogs to follow only the specific human odour of the master and not be diverted by the presence of other tracks.

6. Experiments by MENZEL (Bibl. No. 308) and LÖHNER (Bibl. No. 307) indicated that after a long training a dog is able to identify a piece of wood among many others if his master had held it in his hands for one or two seconds or if he had touched it only with his finger tips for 2 minutes. Even if other people touched the wood before the experiment started, the dog was able to pick it out.

BUYTENDIJK (Bibl. No. 298) demonstrated a similar specific sensitivity for stones thrown by a number of people of which one stone was held for some time in the hand of his master.

7. *Different geological and meteorological factors influence the sense of smell.*

a. *Influence of the soil:* dry dune sand, particularly without vegetation, barely absorbs the odour of shoes; tracks on a rocky soil or asphalt road are practically untraceable (according to MOST); humid sandy soil, even without vegetation, can keep the scent for 12 hours.

b. *Influence of meteorological conditions:* A clay soil with grass and other vegetation, with a humid atmosphere cloudy weather with a light-wind can keep the odour of tracks for 24 hours; dry atmosphere, strong wind and intensive sun irradiation of the soil cause the odour to disappear within a few hours; heavy rain, particularly over a long period, effaces all odours of a track; light rainfall however improves the olfactory reaction.

In all these cases a track of a heavy person can be followed easier than that of a light one.

8. BELLEVILLE (Bibl. No. 295) could prove that dogs cannot determine the direction of movement of the person who caused the track; this is logical considering the mechanism of the sense of smell.

9. Experiments by SCHMID (see Bibl. No. 315) indicated that other animals (dogs, horses, etc.) create a smelling track which can be followed by a trained dog.

The amazing sensitivity of animals to volatile matter is thus sufficiently indicated. Although man in general does not passes this capacity to the same degree it must be remembered that certain paranormal persons might be gifted with an equal extra-ordinary sense of smell. They might be able to perceive certain phenomena which an ordinary person is unable to observe with his senses and which give the impression that supra-normal, non-physical phenomena are responsible for this capacity. We discuss this more in detail in chapter III.

Up till now we have mentioned only one of the senses for chemical excitation, the smell. We shall now discuss briefly *the sense of taste*, which is partly a result of our sense of smell. A real sense of taste exists which is due to certain organs, the *taste buds*, which in man are found only in the oral cavity, on the tongue, on both the anterior and posterior surfaces of the epiglottis, on the inner surface of the arytenoid process of the larynx, on the soft palate above the uvula, on the anterior pillars of the fauces and on the posterior wall of the pharynx. The distribution is greater during fœtal life, in babes and children than in adults The centre of taste shifts with the growth of the individual from the tip of the tongue to a position in the neighbourhood of the circumvallate papillae.

The taste buds contain the *taste-cells*, to which externally thin nerve fibres are attached; the latter are the peripheral parts of the seventh, ninth and tenth brain nerves.

Taste is a composite of four separate senses (sweet, salty, sour and bitter). It has been found that often each papilla and at least each taste bud contains a specific taste-receptive substance that responds exclusively to only one of those four sensations. The distribution of these specifically acting taste-cells is such that the posterior part of the tongue can register only a bitter taste, the borders detecting the sour taste; the tip of the tongue is more sensitive to salty and sweet substances. Mixture of the sputum with a food substance increases the chemical reaction between this substance and the taste-cells.

Sweet taste is excited by alcohols, aldehydes and ketones of the aliphatic series and especially by hexoses and di- and polysaccharides. A few other substances such as chloroform, lead acetate and saccharine act likewise. Probably every "sweet" molecule contains a *gluciphore*, such as CH_2OH-$CHOH$ and an *auxogluc*, such as H-, CH-$_3$, CH_2OH, etc. (see P. BARD: *Physiology in Modern Medicine*, 1941).

Salty taste is aroused by application of chlorides of potassium, lithium, ammonium and magnesium; the bromides, iodides, sulphates and nitrates of sodium and potassium. The taste is probably due to the anions and not to the whole molecule.

Sour taste is aroused by acids, but since one cannot distinguish between pure HCl,

HNO_3 and H_2SO_4, the stimulus must be the hydrogen ion. Certain weak acids can stimulate at lower pH concentrations than stronger acids, probably because of their greater penetration capacity in living cells.

Bitter taste is due to alkaloids and substances such as picric, certain magnesium salts, etc. It has been found that taste buds can be stimulated directly through the oral cavity or indirectly by substances injected into the blood stream.

The following figures may give an idea of the rate of sensitivity of the taste-cells:

Man can distinguish between a solution of NaCl and distillled water even at concentrations of 10^{-4}, but he cannot recognize the salty taste unless the concentration is $5 \cdot 10^{-3}$.

The sweet taste of saccharin can be registered at concentrations of 10^{-4}; the bitter taste of quinine at 10^{-5}; sugar at 10^{-2}; sulphuric acid at 10^{-3}.

Taste sensations can also be created by weak electric currents passing the head. This metal taste is due to the dissociation of the sputum. The alcalic fluid (containing 99% H_2O and 1% solid substance) is excreted by certain glands, the glandulae salivales, of which man possesses three.

The gland cells are rich in blood capillaries and nerve endings, which excrete the sputum only after being reflectorically stimulated by the taste nerves, the excretion pressure of the fluid being abt. 0.3 atm. The sputum contains ptyalin, a fermentive substance that transforms unsoluble amylum into soluble maltose.

The action of the taste cells and the glandulae salivales cause reflectorically the excretion of gland saps in the digestive organs of the body.

The sense of taste might prove to be of importance in the explanation of divining phenomena. In para-normal persons, with a supersensitive sense of taste, excitation of the seventh, ninth and tenth brain nerves through the chemical action of volatile matter directly entering the taste cells in the oral cavity or through the skin and blood stream (see RUSSELL effect page 33-48 and photo dynamic action, see p. 71), might cause excitation of the *gustatory area* in the brain, which, according to BÖRNSTEIN, is situated in the parietal lobe at the foot of the post-central gyrus (see fig. 10 and page 132). Impulses originating in this area may spread through connections with the thalamus (see page 131) to other parts of the cortex (see page 132) and create certain observations or reactions which seem to be caused by supernatural causes. In chapter III we give a few examples of such divining phenomena.

II B. 2: *Sensitivity of animals and man to acoustic waves* (see table p. 28, Bibl. No. 317-350)

Vibrating energy in air may be within the hearing range of the ear, or well above its pitch range, the latter usually described as *supersonics*.

Supersonics follow the same general physical laws as ordinary audible sound but their physiological effects are markedly different, although both are longitudinal waves.

Speech sounds are either voiced, arising from vocal cords, or unvoiced, accompanying air passing through the lips or teeth. The fundamental pitch is the number of puffs of air per second that pass through the vocal cords; they range in general between 150 and 1,000 per second, each sound involving 2 or more important ranges. Most of the power in speech lies in the range 250–1,000 cycles per sec for male and 500–1,000 c.p.s. for female voices. Sounds like "th", "sh" require frequencies of abt. 8,000, which make them so easily misunderstood. The average power of a spoken word is abt. 10 m. watt, in singing abt. 1 watt.

Tones of musical instruments are complex and consist of a harmonic series, the relative intensities of whose components are responsible for the unique characteristics of each instrument. Pitch is called the frequency of the lowest of the harmonic series. Their range of frequencies varies in general between 40 (big bassoon) and 5,000 cycles per second (clarinet).

Pitch of audible frequency of man:

The range of vibrations which can be registered consciously by the human ear is from 16 to 20,000 complete vibrations per sec. The actual sense cells for hearing are hair cells, located in the complicated organ of Corti on the floor of the scala media in the cochlea (see fig. 7),

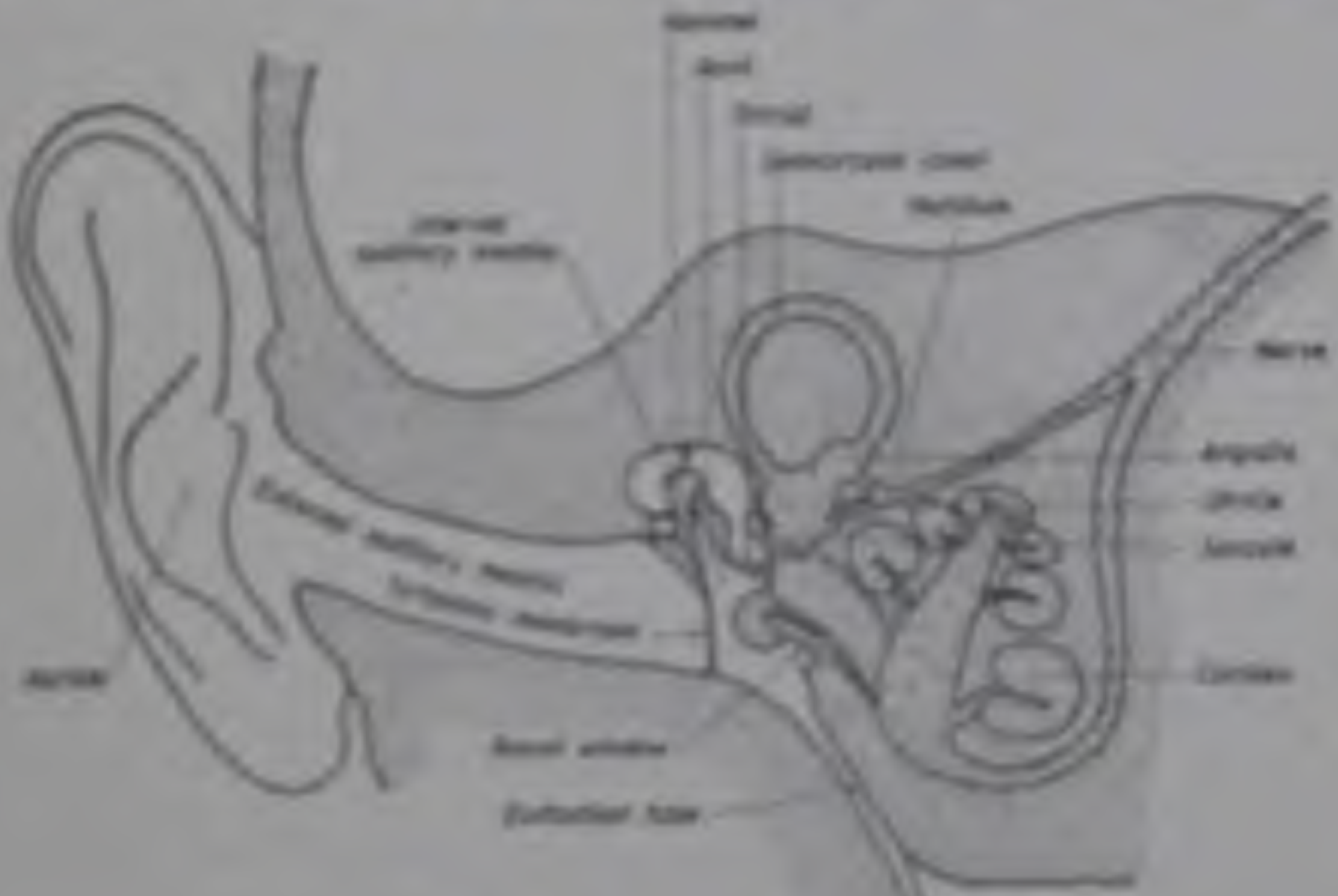


Fig. 7. (Bibl. No. 537) Structure of the human ear.

the tips of whose hairs appear to be embedded in the tectorial membrane (see Bibl. No. 537). According to one hypothesis, the movements of the basilar membrane puts a strain on the hairs, upward movement bending them, downward movement pulling them. The stimulus thus set up is transmitted to the nerve fibers of the nervus acusticus which is connected to the auditory area in the brains (see fig. 10).

Between 100 and 1,000 vibrations, the human ear can distinguish differences in

pitch of 1 vibration per second, at 3,000 vibrations only differences of 10, at 4,000 and above only differences of 40 vibrations per sec can be registered. Altogether the ear can detect 11,000 different pitches, requiring at least 11,000 haircells. The energy required to produce a stimulus at a frequency of 2,048 is less than 0.001 dyne, the energy just observable by an average ear being 10^{-13} erg; this gives a good idea of the sensitivity of the sense organs.

Pitch of audible frequency of animals:

Several animals possess a greater auditory sense than man, either because the structure of the hair-cells and nerves allows vibrations with low intensity to be registered or (and) the range of audible frequencies is greater.

Auditory sense of dogs: The sensitivity of dogs to acoustic waves is almost as important as their sense of smell. Whereas the latter gives information on the immediate surroundings, the audible sense records events happening at great distance; this sense is necessary because his visual horizon is very small. A dog (also a cat) can consciously register vibrations above 20,000/sec, so called *ultrasonic* or *supersonic* vibrations. Artificial supersonic vibrations have been produced up to 500,000/sec. The range of ultrasonic wavelengths in liquids (transmission speed of 1,200 m/sec) is from 6 cm to $2 \cdot 10^{-3}$ cm. They are produced by transformation of electric energy into sound energy, e.g., the method of "magnetostriction" (see p. 80) or a method using piezo-electric phenomena of crystals. It has been found that these ultrasonic waves have peculiar biological effects, which are probably caused by great alternating local pressures, chemical actions and local heating (accompanying these pressures) in the hair-cells (see Bibl. No. 317-335).

Wood and Loomis (Bibl. No. 335) reported that fish, frogs and other smaller animals were killed or lamed in an ultrasonic beam and that filaments of spirogyra were torn to pieces and the cells ruptured.

Transcranial application of a sound beam on the skull of a dog, focused to the proper areas of the cerebral cortex, caused disturbances in muscular coordination and even blindness. Protozoa were paralysed or killed, depending on the length of exposure. Bacteria were not affected, because the whole body seems to be subjected to the same force. However, larger bodies, such as cells, are subject to variations in direction and magnitude of the acoustic pressures at different points of the body, resulting in rupture.

Erythrocytes in physiologic saline solution were destroyed. Porter (Bibl. No. 327) reported a case of a young woman who was extremely rapid and accurate in performing mathematical computations, but who was unable to solve simple arithmetical problems after being exposed to a 16,000 cycle ultrasonic beam for an hour. A chemist, working day after day with a 500 kilocycle piezo-electric source, lost his sense of balance.

These observations were supported by the experiments of Schmitt, Olsen and Johnson (Bibl. No. 330).

According to Schmitt and Uhlemeyer (Bibl. No. 331) *the alternating*

local pressures cause the formation of gas bubbles by *cavitation*, i.e., the presence of hollows in a liquid, formed by tremendous pressure differences existing between the crest and trough of a wave.

Gases dissolved in the liquid tend to fill the cavities and hence form a bubble.

Experiments of HARVEY and LOOMIS (Bibl. No. 322) showed that Arbacia eggs in a supersonic beam were first drawn out into spindle or tadpole shapes and then disintegrated, suggesting that such rapid fluid movement is the result of submicroscopic cavitation. According to STANLEY (Bibl. No. 332), viruses are inactivated by ultrasonic waves caused by production of gas bubbles. In some cases, however, it has been found that this cavitation increases the virulence of pathogenic organisms.

Supersonic waves also cause peculiar *chemical actions* (Bibl. No. 317 and 333); e.g., highly polymerized substances as starch, gum arabic and gelatin are easily depolymerized; the oxidation of potassium iodide is increased, probably by formation of H_2O_2; thixotropic gels (see p. 10) are liquefied by ultrasound in the same way as by shaking; peptization and swelling are accelerated; also strong coagulating effects are observed. Supersonic waves have a dispersive power on crystals in a solution, which are broken up in microscopic bits.

Thermal effects are reported by PORTER (Bibl. No. 327 and 328). Conversion of acidazide into isocyanate was explained by local increases in temperature (up to 30°C) caused by formation of gas bubbles by cavitation. These local effects do not raise the temperature as a whole. However, certain bodies show considerable rise in temperature; e.g., egg yolk after 30 sec exposure to ultrasonic waves increased 11°C in temperature, according to HEIDEMANN (Bibl. No. 323). Heat generation is particularly strong at the boundary surface of two substances traversed by a supersonic beam.

This short summary, of the biological effect of supersonic waves and of the deeper causes of this effect, is necessary in order to appreciate more fully the considerations in this chapter and in chapter III on divining.

The auditory sense of dogs has been studied by a great number of people (see Bibl. No. 336-346).

ENGELMANN (Bibl. No. 341) made some experiments on the horizontal *localization capacity* of dogs. He found that with two shepherd dogs the angle between two sources of acoustic waves and the dog had to be 2°9′ and 3°35′ respectively in order to enable them to distinguish between both sources; with a Dobermann pincher the angle was only 1°26′, with a mongrel 0°51′; in other words the sensitivity of a dog is much greater than that of the average man (angle varying between 4°18′ and 5°43′).

The vertical localisation capacity is only present so long as the acoustic sources are not higher than the head of the animal.

The capacity of estimating the distance of a source of acoustic waves is developed very little with dogs.

The capacity to hear weak vibrations is very great. ENGELMANN found that a steel ball with a diameter of 3.2 mm falling on a steel plate from a height of 3 cm could be heard by a sheperd dog at a distance of 24 m; with man it was max. 6 m. As the intensity of acoustic waves decreases with the square of the distance, the capacity of canine hearing is abt. 16 times better than of man.

In the case of cats the capacity of estimating the distance to an acoustic source and their vertical localization capacity exceeds those of dogs. Cats are also able to register supersonic waves.

The sensitivity to speech-sounds depends to a large extent on understanding of the spoken word. A famous instance is that of the German shepherd dog "Fellow", which belonged to Mr HERBERT, an American. Experiments by WARDEN and WARNER (Bibl. No. 346) confirmed that this dog reacted to 400 different words or commands. The dog knew by name 50 different objects. Experiments by SARRIS (Bibl. No. 345) showed that this capacity of dogs is partly the result of recognition of a certain intonation. Studies by BUYTENDIJK and FISCHEL (Bibl. No. 340) and MENZEL (Bibl. No. 343) suggest, however, that both a dog and a young child partly act on a word as an ordinary signal, such as a whistle, but that also real word-understanding does exist.

Auditory sense of bats:

Recent studies on bats (Bibl. No. 347-350) revealed that these animals possess near the larynx a remarkable organ that produces supersonic waves of a very high frequency, which cannot be heard by the human ear. The frequency varies between 25,000 and 70,000; the number of supersonic squeaks amounts to 30 per sec when the bats are flying. GRIFFIN and GALAMBOS (Bibl. No. 348) discovered that while the squeak is being made a muscle in the ear contracts momentarily, shutting off the squeak and permitting only the echo to be heard, which is reflected by walls, etc.; this permits the bats to evade obstacles in the air. If this organ was removed or both ears covered, the bat would collide continuously against the walls in a room. The existence of natural sources of supersonic waves is most interesting as this phenomenon must be remembered if an attempt is made to explain divining phenomena, and other para-psychological phenomena in general, occurring with para-normally gifted persons [1].

Mechanism of physical diagnosis

The sensitivity of man to acoustic waves has been used in a special method of diagnosis of diseases called *physical diagnosis.*

[1] After completion of the manuscript a book was published by PROF. G. W. PIERCE: "*The songs of insects*", which describes the supersonic sounds made by many insects. He succeeded also in making motion pictures of the singing insects and micrographs of the parts of the insects' bodies that produce the sounds.

It began with the discovery of *percussion* by LEOPOLD AUENBRUGGER and with the introduction of *auscultation* by R. H. T. LAËNNEC; it was further developed and clarified by JOSEF SKODA. As the percussion method has been developed by Dr W. E. BOYD in Glasgow (England) (see Bibl. No. 338a-d) in his *emanometer*, an instrument which uses divining phenomena for diagnosis of certain diseases, we shall discuss briefly the physical background of percussion and auscultation.

Both methods are procedures that depend on the registration of sound created by natural or artificial vibrations in the human body, which set up a series of vibrations carried by air to the ear.

In the case of *auscultation*, the ear or a stethoscope is applied to the chest or heart; some tissues transmit sound better than others, uniform mediums being the best transmitters; soft tissue does not as a rule transmit waves as strong as those transmitted by solid tissue; thus, a muscle does not transmit sound as well as bone.

The sounds produced in the trachea of the lungs have a vibratory rate of 800/sec, in the primary bronchi 1000/sec, secondary bronchi 1200/sec, bronchioles 1300-1700/sec.

The mechanism of heart murmurs is comparable to a fluid flowing through a tube which, after increasing the rate of flow or by constricting or dilating the tube, gives audible murmurs.

Percussion sets into motion waves, the frequency of which can be perceived by our *tactile sense* (see p. 172) or ear.

Percussion of the chest wall causes the thoracic cage and its contents to vibrate; the more force applied during percussion the louder the acoustic tone. The percussion note over the chest is louder than over the liver (using the same percussion intensity) as the lungs, filled with air, vibrate more and produce waves of greater amplitude.

The phenomenon of *consonation*, which causes other objects with the same pitch to vibrate, creates sometimes intensification of certain sounds in the chest. On the other hand, presence of tissues with entirely different vibration rate will cause *dampening* of sound; e.g., the deadening effect of living vibration by the heart and soft tissues.

A sound record of the *resonant tone* (during percussion of the chest) shows that it is not a pure tone but contains numerous overtones with a characteristic timbre.

A *dull tone* (e.g., over the liver) has smaller amplitude, but greater frequency and therefore higher pitch; the waves do not persist very long.

The tone obtained on percussion over the stomach or intestines is called a *tympanitic note*. It approaches more closely a pure musical tone and presents few or no overtones. It usually shows greater frequency of vibrations and lighter pitch.

BOYD discovered, during percussion experiments, that after the application of small concentrations of drugs, there is a slight change in tension over localized areas on the abdominal wall and elsewhere but only if a human subject is at right angles to the horizontal component of the earth's magnetic field. This tension can often be sensed by slight pressure of the palmar surface of the finger, the feeling being very like a faint replica of the sensation of skin "stickiness", noticed if a subject is in a weak alternating field. BOYD claims that homoeopathic concentrations of

drugs (see p. 88) applied to a subject can be detected by measuring this change in tune of a percussed abdominal wall.

He developed a so-called *emanometer* which consists of three parts: 1) an adjustable gap by which a specimen of a drug, etc. on a carrier can be brought near to or withdrawn from the instrumental part of the detecting mechanism (a human subject); 2) a receiving plate attached to a very small coil (continuously tapped and calibrated in length of wire in cm, and designed to alter with minimum change in capacity), a simple condensor system and a switch (designed to reduce to a minimum capacity or resistance change); 3) a biophysical detector, i.e., a human subject, who, when adequately screened, would respond, selectively to the adjustment of the coil, etc., when a stimulating substance (drugs, etc.) is present on the carrier near the human detector. The whole apparatus and the human subject must be adequately screened, by non-magnetic metal or metallic gauze of very close mesh, against external effects.

Boyd admits that he does not yet understand the true nature of these processes and the author, who is not yet sufficiently acquainted with all the details of the method, would hesitate to give an explanation of the Boyd effect. But the above-mentioned physical basis of percussion in connection with the known photo-dynamic action of drugs (see p. 71) indicates that the scientific study of this phenomenon, together with the problem of the influence of homoeopathic concentrations, might prove to be of great value to medical science.

II B. 3. a: *Sensitivity of animals and man to light waves* (see table p. 28, Bibl. No. 351-361)

We have discussed on p. 70-72 the biological effects of light waves on living organisms; there remains only a short explanation of the visual sense of animals and man To birds and man sight is the most important of the senses.

In primitive animals, such as amoeba, the whole surface is sensitive to light and no visual discrimination is possible. In larger animals, however, only certain specialized cells on the surface of the body are particularly affected by the chemical action of light. Those animals are able to *discriminate between light and dark*. If the cells are aggregated in a little patch the *direction* from which the light is coming can be established. Even shadows of nearby objects might be registered, making the patch to a *primitive eye* capable of dicr iminating between *form* and *movement*. In still higher animals the chemical sensitivity of the eye patch on the body can discriminate between different wavelengths (*sensitivity to colour*). Man can distinguish seven colours in the rainbow, but it is quite probable that birds see more. In the higher animals the sensitive patch developed into an organ, a *lens*, which is able to focus the rays of light from surrounding objects so that a *picture* or *image* is formed. This eye lens can be adjusted and by the amount and kind of focussing the animal may learn whether the object is near by or far away (*sense of distance*). The extent of the outside world which is visible at any one time without moving the eye, the *field of vision*, enables the animal to discriminate between distances. Objects further off will have smaller images than the ones nearby. Both the focussing mechanism and the nature of the field of vision determine the *sense of perspective*, which is still further enhanced in animals with two eyes by the overlapping of the pictures taken at slightly different angle in the two eyes. In the

brain they are transformed into one image and give the picture greater perspective or depth, so-called *sense of stereoscopic vision* or *stereopsis*. In the highest developed animals the brains can vary the *amount of light* entering the eye, the *angle of the entering light-beam*, etc. This voluntary control and the *appreciation of the meaning* of things require a good brain. Therefore the amount of use which an animal makes of its eyes and the amount of its control is very largely *conditioned by the type of brain* to which they are connected. For example, birds have control over the size of pupil, which men have not. Individual men vary in their ability to control the eye movements and their focussing mechanism.

Apart from the sense of meaning the *power to remember* visual impressions and the *capacity of taking action* on judgments formed because of them are very important in the processes of visual sense.

Quite complicated action can take place in response to sight without any consciousness, e.g., a seagull catching a piece of food thrown into the air; this is practically entirely due to reflex. Birds possess a keener sight than any animal, but their brains are small.

A bushman tracker has no keener sight than an average man living in town, but his brain attaches meaning to details which are ignored by the townsman. Eye-strain is generally caused, not by the eyes being tired, but by parts of the brain becoming fatigued. *Emotional states, preoccupations and fears are all capable of interfering profoundly with sight*, the eyes themselves being normal. Often a first class brain can be misled by a perfect eye and optical illusion results. One jumps to a *conclusion based on a preconceived idea* rather than on the actual image presented. A good example is the moon rising over distant hills; this may look enormous, although the picture in the eye is the same as that of the moon near the zenith.

All these facts are of importance in the study of reports on experiments on divining phenomena.

The physico-chemical mechanism of the eye (see fig. 8) is based on two principles: the *eye-lens*, which enables the animal to focus the light waves and a *photo-chemical effect*. The latter produces a chemical reaction in the light-sensitive cells, just as a photo-electric cell starts the currents in the eye nerves. Most chemical specializations peculiar to the eye are concerned with the maintenance of transparency (so that the rays may penetrate through the eye tissues into the retina) or with improved photo-chemical reactions.

The *transparency of the eye tissues* is bound up with the swelling and general physico-chemical condition of the eye. The *collagen* in the *cornea* is arranged in criss-crossing sheets of fibres, which make the cornea tough; the swelling is kept constant partly by the constancy of the salts contained in them, partly by the membranes at the front and back of the cornea. Immersed in water it swells to abt. 6 times its normal thickness and becomes semi-opaque to light.

The *eye lens* is not connected with nerves or blood vessels; its clarity depends on the swelling of the fibre-like cells which are laid down concentrically, the whole system being enclosed by a cellophane-like membrane, impermeable to lens proteins, keeping the interior of

the lens in a definite state of swelling. The proteins of the lens are unlike those of any other part of the body, but those different animals seem to be the same and resemble proteins of egg-white. As the animal grows older one of the lens proteins becomes more opaque.

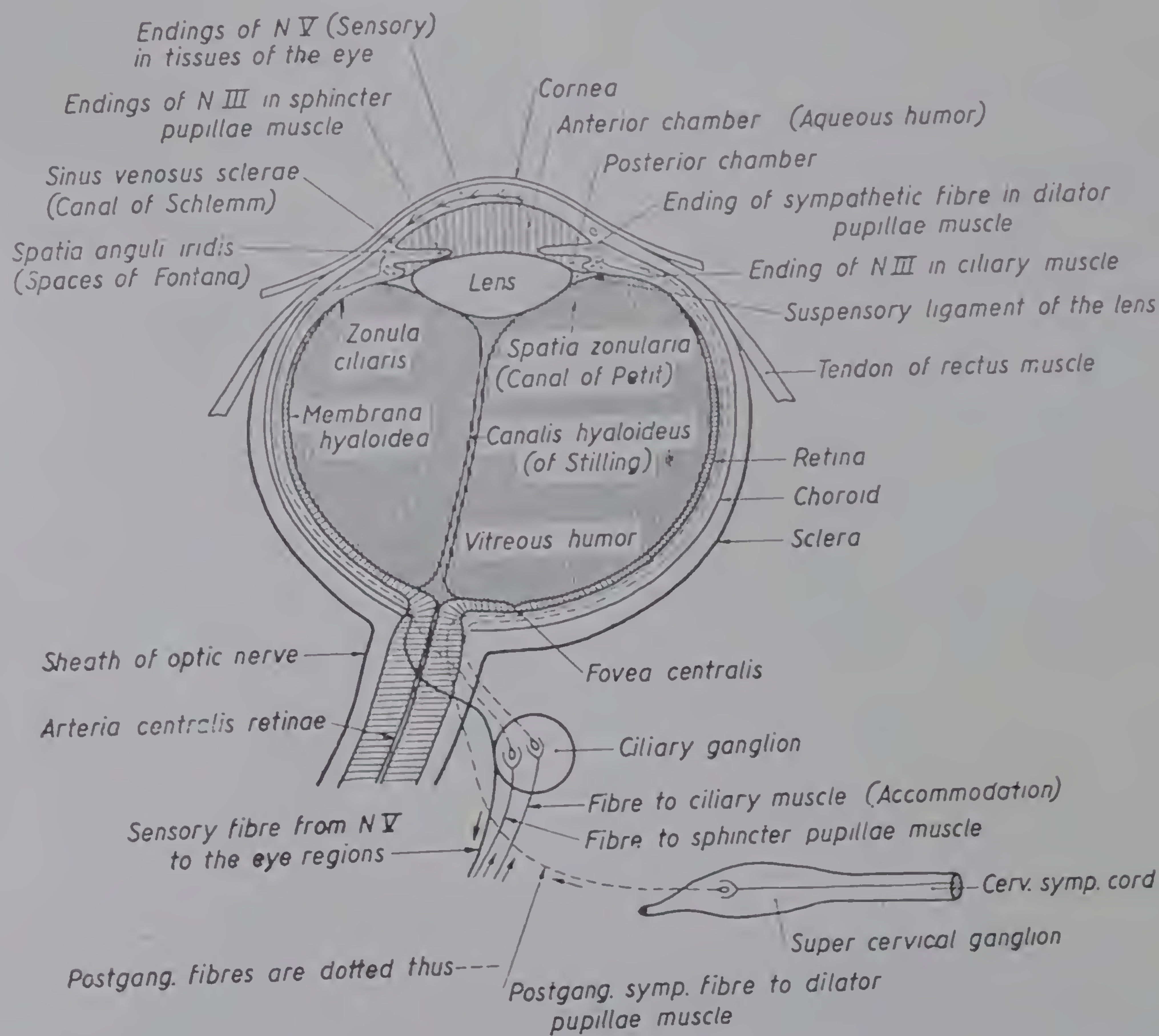


Fig. 8.: (Bibl. No. 337) Main structural elements of the eye.

Between the lens and retina lies the *vitreous*, a rigid jelly composed of 99% water and 1% solid matter, the extraordinary viscosity and rigidity being caused by a polysaccharide, *hyaluronic acid*. Certain enzymes in bacteria can change this viscid jelly into a liquid which is broken up into simpler sugar substances.

Both the lens and cornea obtain their nourishment from a liquid, the *aqueous*, through diffusion. The aqueous is produced by a ciliar body, lying just at the back and at the base of the iris. It contains almost everything that is present in the blood (except proteins) such as glucose, oxygen, inorganic salts, nitrogenous substances, etc. It also contains vitamin C, 20 to 30 times more concentrated than in blood. *The aqueous also keeps the pressure inside the eye ball* (abt. equal to 11 inches of water pressure) *at a constant level*, which is required for constant focussing.

The eye possesses *black and brown pigments* that act as light absorbers. Certain animals, which are active by daylight, have yellow substances that absorb scattered blue light rays and let through the yellow rays to which the retina is most sensitive. They act as extra-ocular filters and increase the contrasts of the picture. The human eye has a yellow

pigment just on the *macula*, which is the point in the retina where we have most accurate vision. The colourless lens turns yellow with age; as a result the lens of a child lets through 90% of the blue light, compared with 15% in the case of a man of 78.

Some animals (squirrels, prairie dogs, etc.) keep yellow lenses throughout life. Some fish have bright yellow corneas. The cone cells of the retinas of birds, frogs, and turtles contain yellow and red oil droplets which filter the light before it actually strikes the cell.

The process of vision in higher animals consists for the most part of three processes: *light perception*, *colour perception* and *stereoscopic perception*, all three being related to the anatomical and chemical structure of the retina.

The retinas of most vertebrate animals contain two types of cells, the *rods* and the *cones*. The rods are mainly concerned with perception of light of low intensity, the cones are used for acute vision in bright light and colour perception. As a result birds (except the owl) and other day-loving animals contain retinas mainly composed of cone cells; cats, rats and mice have largely rod cells in their retinas; man has about 20 times as many rods as cones; most great apes have mixed retinas.

Many rod cells may be connected to one nerve cell and fibre, while cones, particularly the macular type, tend each to connect with a single nerve cell. As a result rods transmit a light stimulus in a rather fuzzy way; each cone, however, transmits a separate message to the brain, giving a very clear, sharp impression.

Just as the fineness of detail visible on a photographic plate (see p. 33) depends on the fineness of the emulsion of silver bromide on it, so the detail of retinal image and the impression on the brain depends on the size of light-receiving cell and on the individuality or complexity of its connection with the brain. The changes that take place in the retina of vertebrates and man upon stimulation are action currents, bleaching of the so-called visual purple and for the lower vertebrates, movements in the rod and cone cells and migration of pigment. We shall review each of these phenomena separately.

It has been found experimentally that light shining on the eye causes a regular sequence of uniform electric charges that travel along the nerve and vary for each wave-length; for weak illumination the frequency of electric charges increases with the square root of the intensity. The action currents (see p. 139) are more complicated than the muscular currents and are complex mixtures of negative potentials and slow positive ones, the locus of action being in the synaptic (see p. 128) layers of the retina, i.e., proximal to the rod and cones. The transformation of chemical into electric energy is partly caused by the presence of a light-sensitive substance which bleaches when brought into light, the so-called *visual purple* or *rhodopsin*, a protein compound related to vitamin A (a substance present in vegetables).

It is present in rod cells of the retina of mammals, birds, reptiles and amphibians, but probably not in the cone cells. The substance that causes light sensitivity of the cone

cells is not yet known with any certainty. According to certain research workers it is *iodopsin*, a conjugated carotenoid protein. Marine fish possess rhodopsin in their retina, but fresh water fish have a different substance called *visual violet* or *porphyropsin*, which seems linked somehow with the spawning habits; marine fish coming up the rivers to spawn have the same type of substance in their retinas.

Visual purple does not absorb all light waves to the same extent. Being a red substance it does not absorb red light and for this reason red colours appear black to us in dim light; greenish yellow light is absorbed most, our eyes being most sensitive to this wavelength.

The bleaching of visual purple seems to occur in several steps: first "transient orange" is formed, a substance little affected by changes in pH concentration; it is converted thermally into "indicator yellow" and finally into a colourless substance. On withholding vitamin A in human experiments it was found that after 35 days the minimum threshold value for cones may be 3-4 times the normal, for rods 9.1 times. Administration of β carotene (see p. 13) almost immediately restores the normal sensitivity (in less than an hour).

The chemical basis of adaptation of our eyes to darkness is the result of an accumulation of visual purple in the rods in dim light. After adaptation the eye becomes 10^4 more sensitive than when it is light-adapted, and a fully dark-adapted eye is more sensitive in registering light energy than most known photo-electric cells. It has been found that an eye can just detect a light flux of $1.7 \cdot 10^{-9}$ ergs/sec, which is sufficient to bleach 5-14 molecules of visual purple.

Contrary to the photographic plate the eye is able to build up a light-sensitive surface after each exposure, making vision a continuous process.

The light-sensitive substance of cone cells is less sensitive than that of the rod cells as otherwise it would be out of action in daylight. It is most sensitive to yellow light, whereas visual purple is sensitive to yellow-green. At dawn, therefore, red flowers appear black, others grey, but as the sun gets up yellow flowers stand out against grass which looks grey.

A normal person can distinguish 160 colour shades in sunlight, yet it has been found that all can be made up of mixtures of red, green and violet. Therefore in order to see those 160 shades we do not need 160 different receiving cells. The YOUNG-HELMHOLTZ *theory* assumes that the retina contains only three different types of cone cells, one sensitive to red, one to green and one to violet, creating different electric impulses on the nerves. Also, different types of nerve connection with the eye cells might be responsible for the *mechanism* of *colour vision*. A defect of colour vision is called *colour-blindness*, which affects abt. 4% of men and 0.4% of women; dogs are practically completely colour-blind and see only shades of grey.

If the red pathway is missing in men, they are called *red-blind* or *protanopes*; if the green pathway is missing they are called *deuteranopes*. Frogs seem to be totally colour-blind; birds can probably differentiate more hues than men, particularly at the red end of the spectrum; amongst mammals there is no evidence of colour vision.

In lower vertebrates the cones shorten on exposure to light (some evidence points also to lengthening) and the pigment migrates forward to surround the cones and rods.

The *sensitivity of the retina* is determined by two factors: the energy incident on the retina and the time during which it acts. The first factor depends upon the intensity of the light and the area of the retina exposed.

According to the BUNSEN-ROSCOE *law* the product of intensity and exposure time is constant for a given effect (see p. 99, phototropic and geotropic "law of constancy of excitation energy").

According to HARTLINE (Bibl. No. 356) the threshold value of an eye adapted to the dark is $7 \cdot 10^{-7}$ millilambert; a dark-adapted eye can stand only 25 millilamberts; if adapted to bright sunlight 16000 millilamberts; the limits of visibility are 330 mμ in the ultraviolet (for the dark-adapted eye) and 900 mμ in the infra-red, the usual range being between 396 and 712 mμ.

The analysis of the visual sense of animals and man indicates that a great number of external forces, which were discussed in previous pages, are able to influence this sense and the action of our brains (see also p. 145, encephalograms). This knowledge is of great importance for the study of divining phenomena, especially from the para-psychological viewpoint, as the emotional state of para-normal persons might considerably influence their visual sense. The range of visual observation of para-normal persons and the structure of the retina of their eyes might be different from normal persons, and enable them to observe phenomena which cannot be registered by normal persons. Care is needed in forcing a diviner to close his eyes during a scientific test as closure of the eyes definitely involves a change in the action of the brain. On the other hand sufficient precautions must be taken during those experiments as the visual sense might be very great, comparable to that of extremely sensitive animals.

Finally we must bear in mind the possibility of radiation by the eye. Many photo-chemical substances are able to absorb light which is released again as fluorescence or phosphorescence (see p. 30). A similar phenomenon might occur particularly with para-normally gifted persons.

II B. 3b: *Sensitivity of man to Hertzian waves* (see table p. 28)

We have considered on pages 65 and 68 the influence of *Hertzian waves* on living matter. A few more examples are discussed in chapter II on p. 282-285.

II B. 3c: *Sensitivity to heat-waves* (see also p. 71, Bibl. No. 362-376)

OPPEL and HARDY (Bibl. No. 369) studied the response of the skin to heat radiation, caused by the infra-red spectrum. BAZETT classifies the infra-red spectrum in *near infrared* (760 mμ-150 μ), *intermediate infrared* (150-300 μ) and *far infrared* (wavelengths greater than 300 μ). The part of the spectrum with wavelengths shorter than 300 μ was designated as *penetrating infrared*, that of longer wavelengths as *non-penetrating infrared*.

Specific stimulating quantities of various radiations were measured for white men and negroes. The ratio between the minimum amounts of incident radiation required to evoke sensation for visible red, penetrating infrared and non-penetrating infrared were for white subjects 3 : 2 : 1;

allowing for reflected energy the ratio 2 . 2 : 1 . 5 : 1. Negro subjects gave 1 . 5 : 2 . 5 : 1 . 3.

The skin surface temperature is elevated highest by non-penetrating infrared and least by visible radiation, part of this difference being caused by reflection of visible rays and penetration of infrared rays.

The smallest rate of radiation which the body is capable of perceiving as warmth is $15 \cdot 10^{-5}$ gcal/cm²/sec = $63 \cdot 10^{2}$ erg (1 gcal = 4.2×10^{7} erg). Sensation is evoked in 3 sec by exposure of 200 cm² surface to such a stimulus that the total energy exchange for sensation is 0.09 gcal. This equals abt. 10^{-7} of the normal hourly radiation loss from the body surface.

The skin temperature change caused by this radiation is a total elevation of 0.003°C, produced at the rate of 0.001°C per sec.

Immediate local effects induced by local exposure to heat waves are stimulation of the vasomotor mechanism and the sensory nervous system of the skin (see p. 172).

1. It induces profuse *sweating* which changes the electric resistance and conductivity of the skin (see p. 183). Insensible loss from the skin amounts to 15 ml/m²/hour under normal conditions, but can amount to 500 ml in case of gross sweating, which causes a loss of weight up to 2¼ lb/hour. Sweat is composed of water and 0.1-0.5% sodium chloride, but also other substances, normally found in urine, may occur such as urea, ammonia, uric acid, amino acids, creatinine, phosphates, sulphates and sexual hormones. There are two active substances in the urine of the adult male, *androsterone* ($C_{19}H_{30}O_2$) and *testosterone* ($C_{19}H_{28}O_2$). These influence the sexual functions and have a depressive effect upon the anterior lobe of the pituitary gland (see below).
   Sexual hormones such as *theelin* ($C_{18}H_{22}O_2$), *theelol* ($C_{18}H_{24}O_3$), etc. occur in the urine of females. The quantity present varies in relation to the menstrual cycle and has two peaks, the first and smaller at about the mid-menstrual period and the second in the early part of the last week preceding menstruation. There is a gradual rise in excretion of these substances during pregnancy; another substance, *progesterone* ($C_{21}H_{30}O_2$), occurs in these circumstances. The presence of these substances in varying quantities in the urine of man and therefore also in small quantities in sweat might be of great importance for the varying electric conditions of the skin and can explain several of the divining phenomena discussed in chapter III (see also p. 201, studies of BURR).
2. Heating causes also can almost instantaneous change in the *heart rate* (see p. 152).
3. Mild heat produces a slight fall in *blood pressure*; with greater heat the heart rate and blood pressure increases.
4. The *respiratory* reaction increases in proportion to the rate in rise of temperature.

5. Rise in body temperature increases the general *metabolism* and carbon dioxide is formed in larger quantities. Increased metabolism increases the breakdown of proteins in phosphates and sulphates which escape through the urine. Loss of acid substance renders the blood more alkaline, which in turn influences the heart.
6. Heat causes increased *lymph formation* and stronger lymph flow through the lymph capillaries. At 50°C and above irreversible changes in capillary permeability occurs.

These few examples indicate the great influence of external heat radiation on the general condition of the body and its components.
Both electric and physico-chemical properties of the cell and cell-groups in the living body can change fundamentally as a result of this external irradiation.

Certain processes in the body can lower the temperature of the air in the neighbourhood of the body. This is the result of absorption of heat energy by the body or to reduced heat loss. The effect be felt as a sensation of cold by another body nearby. Such phenomena were observed during experiments with highly strung para-normal persons (Bibl. No. 365, 366, 370, 376).

PRICE (Bibl. No. 373-375) reported lowering in temperature of the room of 4°F. The body temperature of a famous para-normal person (STELLA C) at the end of the experiment was abt. 0.5-1°F higher than before. Experiments by RUDI SCHNEIDER, (Bibl. No. 374), who used selfregistering thermometers, indicated a lowering of the room temperature of 1.5°F, max. 2.95°F. People in the neighbourhood registered a sensation of cold. DUDLEY (Bibl. No. 365) reported a change in temperature of 15°F with a para-normal woman (MARGARY) in the U.S.A. The energy absorbed to lower the temperature of 1 litre of air, at normal pressure and constant volume, with 1°C is abt. $2.2 \cdot 10^{-4}$ kcal (1 kcal = 427 kgm). In a room of $3 \cdot 3 \cdot 3\ m^3 = 27\ m^3$ this would amount to abt. 6 kcal, the heat loss of the body under normal conditions amounting to abt 810 kcal/hour = 13.5 kcal/min.

In order to explain this thermal effect of para-normal persons we must analyse the mechanism of the body temperature. The latter represents a balance between heat production and heat loss. The body itself regulates this balance.

Heat production occurs mainly in the *skeletal muscles* (see p. 161) where exothermic oxidative and non-oxidative reactions are constantly going on; increase in muscular activity raises the body temperature by 1° or 2°C. Lowering of the environmental temperature causes an increase in tone, a "tensing" of the muscles, mostly followed by synchronous contractions of muscle fibres, known as shivering. Heat is produced also by *chemical processes* occurring *in the liver* and other viscera and *by the heart*. The specific dynamic action of foodstuffs also frees heat. It is well known that the *metabolic rate* (particularly protein metabolism) *is influenced by several glands of internal secretion*, particularly the *thyroid*, which might lower the rate of combustion to a level abt. 40% below normal, the secretory activity of the thyroid being under control of the anterior lobe of the pituitary gland (hypophysis) which exerts its influence

through the secretion into the blood of a thyrotropic hormone.

It was observed recently that never fibres pass from the hypothalamus (see p. 130) to the hypophysis by way of the hypophysical stalk. Long exposure to cold seems to cause production of increased amounts of thyrotropic hormone by provoking a discharge of nerve impulses over fibres belonging to the hypothalamico-hypophysial system.

Another endocrine gland that seems to possess a calorigenic action in the body is the *adrenal medulla*, which is also subject to rapid changes in activity induced through its nerve supply.

This gland produces *adrenalin* which, administered to the blood in high dilution, lowers the blood pressure, the effect being largely the result of selective vasodilatation in the arterioles of the skeletal muscles. The adrenal cortical hormone also affects on protein metabolism.

Heat loss is effected mainly through the skin, but partly through the respiratory tract and lungs. The *loss through the skin* takes place for the most part by *radiation* (the amount being determined by the surface of the body, its emissive power and the difference between the fourth power of the absolute temperature of the radiating body and the fourth power of the absolute temperature of the object towards which it is radiates, the wavelength varying between 5 and 20 μ), *convection* (absorption of heat by air passing the body) and *evaporation of water* (evaporation of 1 gram of water, at room temperature, from the body surface requires 580 gcal; evaporation therefore causes loss of heat, condensation increases the temperature; the total amount of evaporation depends on the surface, temperature of the surface, vapour tension and movement of the air, electric potential of the skin, see p. 174). *Loss through the respiratory tract and lungs* takes place mainly by *evaporation*, partly by convection. *Conduction* is rarely an important means of heat loss unless the body is in contact with a good conductor.

According to RUBNER, ALDRICH and MARTIN the total heat dissipated by a man, clothed and sitting in a room at 15°C, air 50% saturated, is about 44% by radiation, 31% by convection, 20% by evaporation from skin and lungs. In the case of a naked man at 27.4° C and humidity of the air of 25% the loss is 58% by radiation, 27% by evaporation and 15% by convection. We have seen on page 70 that water vapour absorbs almost completely the infrared terrestrial radiation (4 — 50 μ). Increased sweating might surround the body with an aura of great humidity which absorbs to a considerable extent the heat radiation of the body.

The above, mentioned phenomena indicate that para-normal persons with peculiar actions of the thalamus (see p. 131) are able to change fundamentally the metabolic processes and heat production; the abnormal electric charges of the skin of these persons (see p. 175) might create vapour condensation on the skin and a decreased body radiation of infrared rays. These and similar processes, which require further studies, might explain the *thermal effect* that accompanies many para-psychological phenomena and be of importance in understanding some of the divining phenomena discussed in chapter III.

Further experiments on the changes in the infrared radiation spectrum of para-normal persons, which were initiated by BOYD (Bibl. No. 338a-d) in his studies on the influence of homoeopathic concentrations on the

human radiation, might give a clue to this complicated problem and could be of great significance to medical science.

II B. 4: *Sensitivity to magnetic excitation*
(see table p. 28, Bibl. No. 377-382)

On page 79-84 we discussed the mechanism of bio-magnetic effects. A summary of experiments on the biological effect of magnetic fields is given in chapter II on p. 264-282. An exception will be made for a few experiments that indicate the influence of magnetic fields on nerves.

Whereas an enormous number of experiments have been carried out on electric excitation of nerves, the influence of magnetic fields has been largely neglected; the scientists who did study these phenomena have been apparently forgotten. There are no data on this subject in the English, American or Dutch literature.

In 1887 experiments were carried out by HERMANN (Bibl. No. 379), Professor at the Physiological Institute of Königsberg (Germany), on the influence of a non-alternating magnetic field on nerves and on muscular contraction. He could demonstrate that:

1. magnetic fields can create induction currents in the nerves of frogs, which can be registered with an ordinary stringgalvanometer;
2. these induction currents are insufficient, in case of one single nerve fibre, to stimulate the muscular nerve to such an extent that a muscle connected with the nerve can contract.

HERMANN drew the erroneous conclusion that this second result proves that magnetic fields have no biological effect, this probably being the main reason of the publication being forgotten in the 20th century. In point of fact this experiment was the first proof of a biological effect. On p. 136 we point out that a motoric nerve in vitro can be stimulated by a current of 10^{-6}-10^{-9} ampère, that every current, even a very weak one, always excites a nerve, although there may be no apparent external result, and that a continuous excitation at short intervals with currents below the threshold value (for stimulating a nerve) can enable the excitational energy to reach the threshold value and cause an externally visible reaction on muscles. Although magnetic induction in a nerve in vitro creates a current below the threshold value, continuous excitation of a number of nerves in the body might help to reach the threshold value of nerve action (see also p. 98, law of TALBOT).

In 1888 experiments were carried out by SCHIFF (Bibl. No. 380) which gave the following results:

1. the latent period (i.e., the period between the beginning of the excitation and the first observable external change) of neuromuscular tissue is decreased if the nerves are brought into a magnetic field;
2. the general sensitivity of animals increases.

GRANDIS (Bibl. No. 378) discovered in 1902 that the conductivity of nerves seems to increase after treatment in a magnetic field.

In 1903 DANILEWSKI (Bibl. No. 377) repeated HERMANN's experiments with alternating magnetic fields with a frequency of two per second. The original Russian publication is not available but a summary is given by SSAWOSTIN (Bibl. No. 381). DANILEWSKI found that muscles contract if the muscular nerves are subject to the action of alternating magnetic fields. Whether this effect is due to Hertzian waves rather than to a purely magnetic effect cannot be established from the summary.

These few reports support our statement (on page 84), that magnetic fields acting continuously during long periods can cause a bio-magnetic effect.

The author made a number of experiments on the influence of magnetic fields on muscular concentration of man (Bibl. No. 382). These experiments are described on page 311, chapter III. It has been possible to prove that a disturbance in the contraction of the armmuscles (the arm holding a divining rod or a pendulum) is created if a magnetic field, created by a current in a circular conductor with a diametre of 1 metre (see fig. 96), is switched on or off. Gradients of the field strength of 0.001 Gauss per cm and less can be registered.

II B. 5: *Sensitivity to electric excitation* (see table p. 28)

We consider on pages 135 and 165 the electric excitation phenomena, both of nerves and muscles, created by direct contact with a source of electrical energy or indirectly through induction. An exception is made now for the electric induction phenomena of nerves.

The first experiments on the influence of alternating electrostatic induction on nerves were made by GENGERELLI and HOLTER (see Bibl. No. 383). The set up used consisted of a pair of condenser plates $9^1/_2/4$ inches, separated by a distance of 7 inches. A potential difference of approximately 10,000 volts was established between these plates at a frequency of 60 cycles. The preparation of a frog nerve was extended on a carefully cleaned glass slide and placed between the plate of the condenser. The glass slide could be rotated to any desired angle with the electric lines of force between the condenser plates. At an angle of 70° between the glass slide and the lines of force the intensity of contraction began to increase until the maximum was reached at the moment that the nerve axon was parallel to the lines of force. This result was obtained only if the proximal end (i.e., that nearest to the muscle) of the nerve was 5 mm long; if the distal segment was used the nerve had to be at least 18 mm long.

No reaction was obtained if the nerve was surrounded with a saline solution. The fluid apparently acted as an effective electrostatic shield.

These experiments cannot be considered as being conclusive as concer-

ning the real effect that causes the nerve action. It is not to be excluded that Hertzian waves are created, which might be partly responsible for the effect.

II B. 6: *Sensitivity to mechanical pressure* (see table p. 28)

The different sense organs comprise the *receptors* which are distributed throughout the body. They are divided into organs of *cutaneous* and of *deep sensibility*, depending on whether the receptors lie in the skin or in the internal parts of the body.

Four primary qualities in sensations are distinguished: touch, heat, cold and pain. It has been found that definite spots on the skin give rise to one or another of these sensations. Some give rise to touch only, others to warmth, etc. The touch spots are stimulated by pressure that deforms the tissue. We mentioned on page 19 the origin of *compression potentials* as resulting from mechanical pressure. The structure and function of the receptors of touch are discussed more in detail on p. 172 (see also p. 132).

III: *Summary of energetic conditions of "life" required for existence on earth* (see table p. 28)

We have seen that every living body is extremely sensitive to physicochemical influences. Because of this fundamental property of living matter, human beings and other more developed animals can live on earth only within certain physical limitations. The following nine limitations determine the type of living bodies encountered on earth.

1. *A certain temperature interval is required.* This is mainly the result of the structure of the colloidal proteins which form an important part of the cell-protoplasm and which, after heating, coagulate or completely disintegrate. Fluids in or between cells solidify at low temperatures. Although certain adaptations are possible (e.g., organisms in hot springs are composed mainly of lipoids, which have a higher coagulating point than proteins) temperatures cannot surpass certain known physical limitations.
   The sun, with a surface temperature of 12000° F is just far enough away. If the sun gave off only half its present radiation we would freeze; if it gave half as much more we would "roast".
2. *An atmosphere* is needed to give the necessary oxygen. It is required also for other reasons:
   a. It regulates the temperature on earth as it acts as a heat reservoir for the rays of the sun. Without atmosphere we would die from heat in the day and freeze to death in the night.
   b. The cell tissues of organisms require water; the atmosphere is the most ingenious moisture regulator we know.

c. Because of the atmosphere, and the topography of the earth, we have rainy periods which result in the solid earth crust becoming eroded; the fine erosional products, often with a concentration of useful inorganic salts, make possible life for the higher plants, plants which man needs for food and existence.
d. If our atmosphere had been much thinner, some of the meteors, now burned in space by the millions every day, would be striking all parts of the earth, creating fires everywhere and destroying our cities.

3. *The gravity of the earth* needs to be within certain limits:
   a. Man and highly developed animals can move because their muscles are capable of developing certain forces greater than gravity, but not so much greater that jumps are followed by a drop too much for our weak body. Gravity conditions on the moon might allow the existence of organic life but considerable muscular adaptations would be required, which in turn would create organisms completely different from the organic life on earth.
   b. Our atmosphere would be much lighter if the gravity were smaller, the atmosphere would expand, consequently the oxygen ratio would be much smaller and present organic life could no longer exist.
   c. Movements of the earth crust and volcanic eruptions would be so much more violent than at present that large areas of the present earth crust would be impossible to live on.
4. *Certain ratios of the elements on earth* are required for present day organic life; in this respect the carbon content is very important. It is because of these ratios that at a certain stage of the cooling of the earth complicated carbon compounds originated by polimerization processes, which ultimately created the vegetable cell. Only carbon has the unique property of forming long molecular chains which build up the complicated cell bodies with their eight fundamental properties of life: food consumption, respiration, growth, reproduction, irritability, capacity to move, regeneration and selfregulation. It has been shown by the author (in his publication "The religion of the modern scientist", SYTHOFF's Publ. Co., Leiden, 1947) that these properties, although less complicated, exist also in the non-living inorganic world.
5. The organic life on earth developed in close cooperation with the *geological developments of the earth crust*. This development of the earth requires a certain web of forces and a certain history for the earliest stages of the development of the earth. It is doubtful whether this extremely complicated group of conditions has been repeated in the universe (the chance seems to be abt. one in every 10 billion years).
6. *The rotation of the earth* should not be considerably slower. At present the earth rotates at a speed of 1,000 miles per hour; if the speed were only 100 miles per hour, day and night would be 10 times longer:

the sun would burn the vegetation during the day, while we would freeze during the night.

7. *The axis of the earth*, tilted at an angle of 23° creates the seasons. If it had not been tilted vapours from the oceans would move north and south, piling up continents of ice.
8. If the *distance to the moon* were considerably smaller, e.g., 50000 miles, the tides would be so enormous that the continents would be submerged twice daily and the erosion of mountains would be tremendous.
9. If the *thickness of the earth crust* had been 10 ft thicker there would be no oxygen left for animal life.

This concludes the section "the limit of sensitivity of protoplasm to physico-chemical influences." We know now that the living body is continuously subject to physico-chemical processes as a result of external physico-chemical fields. The discussions form the basis of a steep pyramid, of which the apex is composed of the divining phenomena. Without this solid basis any attempt to climb the pyramid is doomed to failure and it is this knowledge, we hope, that will satisfy the impatient reader who might have wondered whether this is a book on physical chemistry and physiology or on divining.

2. A. 5. Main laws of cell development.

It has been found that the different processes of development after fertilization of the eggcell do not take place haphazardly but are ruled by a group of laws, each of which finds its counterpart in the inorganic crystalline world. It would be out of the scope of this publication to give a complete review of these laws, the more so as they have been dealt with already by the author in his publication "The Religion of the Modern Scientist" (SYTHOFF's Publ. Co., Leiden, 1947, p. 176-189 and p. 193-198).

The main laws of reproductional development can be applied both to animal and plant life and can be summarized as follows:

1. *Law of constancy of chromosomes:* In the inorganic crystalline world the counter law is probably the "law of constancy of angle of crystal faces."
2. *Laws of symmetry:* It is well known that all solid crystalline forms in nature can be brought back to 142 fundamentally different crystal species, which can be classified into 32 classes of symmetry, belonging to 7 crystal systems. Those 142 fundamental forms are the result of 230 fundamentally different point systems of the space lattice structure of crystals. The variety of form is created by the distribution of the three main elements of symmetry in crystals: *planes*

of symmetry, axes of symmetry (gyres or axes of rotation and gyroids or axes of rotary reflection, bipolar or polar respectively, only two, three, four and six-folds axes being possible) and *the centre of symmetry.*

It has been found that all things, both in the inorganic and organic living world have the tendency to orient themselves, a phenomenon known as *crystallization* in the inorganic world and *polarity* in the organic living world. It is because of this phenomenon that a surgeon transplanting a piece of skin from one body to another must take care to place the originally lower part of the transplanted skin on the lower part of the wound of the patient, otherwise the wound would be unable to heal. The same law determines the constancy of angle between stem and stalk of plants, their constancy of leaf distances, etc.

Studies by SPEMANN a.o. revealed that the cleavage plane of reproducing cells and the plane of symmetry of the future embryo have a specific relationship (see also experiment of BURR, page 200) similar to the cleavage phenomena in crystals.

All these properties of the living cell are the result of the crystalline structure of the micellae (see p. 9).

3. *Laws of directed reproductional phenomena.*
   a. *Laws of regulation:* It has been found by the experiments of H. SPEMANN, H. DRIESCH, W. ROUX, G. R. HARRISON, J. A. BIERENS DE HAAN a.o. that up to a certain stage of reproductional development the processes are *regulated* by a certain crystallizing force. As a result, after the second cleavage of the fertilized egg of a sea-urchin, the four egg cells can be separated and each will grow out into a complete sea-urchin.
   b. *Laws of determination:* At a certain stage of development this regulating force changes to a *determinating* force. This moment varies for the different properties to be determined.
   c. *Laws of induction:* SPEMANN found that up to a certain stage of development a cell or cell group is determined only by its surrounding cells and not by its place of origin. After a certain stage however, the development is determined only by its place of origin. If, e.g., during the later gastrula stage a part of the ectoderm, which normally develops into a mouth is transplanted in a place where normally the abdomen is formed, one observes later the development of a second mouth in the abdomen, in other words the mouth properties were *induced* in the abdomen cells.
   Examples of the law of determination and induction are also known in the inorganic world. We gave on page 32 an example of induction of aragonite or calcite properties in a crystallizing solution.
   d. *Laws of regeneration:* The capacity, particularly of the lower organisms, to rebuild lost organs is well known. A famous

example is the *planarias*, a kind of worm, which, after being cut up in 250 parts, regenerated into 250 new worms. This phenomenon is not restricted to the living world. In the above mentioned publication the author has given ample evidence for this statement. The law of regeneration and other laws mentioned on page 127 are all due to the crystalline structure of the fundamental components of the cell.
This brings us to the end of the section on the "cell", the first main component of the electric field in man.

B. The Nerve
(see Bibl. No. 384-411)

The nerve is the second important component which determines the electric field in man. A short summary is be given in the following pages of the following properties of the nerve:
1. Structure of the nerve cells
2. Law of constancy of nerve cells
3. Laws of electric excitation
4. Laws of chemical excitation
5. Mechanism of nerve conduction
6. Influence of the medium surrounding the nerve membrane.

2. B. 1. Structure of the nerve cells

Three processes occur in unicellular organisms when a response is brought about by a stimulus: *excitation* (the setting up of a physiological disturbance), *conduction* (spreading of the disturbance to parts of the cell remote from the point of excitation), *response* (on the part of the protoplasm to which the disturbance has spread).

In the multicellular organisms the same processes take place only if the conduction is intercellular, in other words the disturbance spreads from one cell to another.

The first nervous tissue appears in the group of *Coelenterates* as a network of nerve cells. The responses are diffuse in character in these animals and the rapidity with which impulses are conducted are only 130 mm/sec (i.e., 200 times less than the velocity of a nerve impulse in the motor nerves of the frog).

In higher forms of animal life the nerve cell system is characterized by selectively discharging impulses from different receptors to effectors; the latter create a coordination between the different parts of the body.

The *central nervous system* of the higher animals is composed of nerve cells, so called *neurons*. They are cells 4-100 μ large, globular, pear-shaped, spindle-shaped or pyramidal in shape, the internal part (the *cellbody*) composed of protoplasm with many fibres, a round nucleus with nucleus membrane and one or two core bodies. From each nerve cell numerous short processes extend, the *dendrites* (i.e., ramified proto-

plasmatic offshoots) and one long fibre, the *neurite* or *axon*, which is a branched protuberance of the nerve cell reaching dimensions up to 1 metre in length. The branches of the axon are called *collaterals*.

A number of these neurites, each surrounded by connective tissue, form the nerve fibres; these, grouped together into nerve bundles, create the actual *nerve*. From the centre outwards the following units can be distinguished in a nerve:

1. *Neurite or axon:* composed of a number of parallel fibres the *neuro-fibrils* (the actual conducting substance) stuck together by a substance called *neuroplasm*; it has been found that these fibrils show positive uniaxial birefringence and are composed of proteins or conjugated proteins, structurally arranged into sub- microscopical rodlets, which show an extremely regular banded structure under an electron-microscope.
2. *Membrane of* MAUTNER: surrounding the neurite.
3. *Myelin or Marrow sheath:* a thick, very viscid substance, which acts as an insulating layer of the neurite; it consists of very thin sub-microscopic concentric layers of proteins (neurokeratin), intercalated between layers, possibly 4 molecules thick, of mixed lipids; the myelin is interrupted at regular intervals and form constrictions known as nodes of RANVIER; the myelin sheath is missing with the sympathetic nerve system and young embryos.
4. *Sheath of* SCHWANN: a fine layer, missing in the central nervous system and olfactory nerves.
5. *Sheath of* HENL: outer layer of the *nerve fibre* (including 1-5), missing in the central nervous system.
6. *Endoneurium:* connective tissues separating the different parallel nerve fibres in a nerve bundle.
7. *Perineurium:* connective tissue surrounding a group of parallel nerve fibres and forming the actual *nerve bundle*.
8. *Neurilemma:* connective tissue surrounding several nerve bundles and forming the outer layer of the nerve.

Nerves can therefore be compared with marine cables composed of different insulated wires. They are divided into *myelinated* and *unmyelinated nerves*. The simplest kind of unmyelinated fibre occurs in the mammalian central nervous system. It consists of protoplasm surrounded by a very thin cell membrane. In the periphery it is also surrounded by a thin neurilemma sheath. In the central nervous system the myelinated fibres have no nodes of RANVIER and no sheaths of SCHWANN and HENL (see also p. 140).

Most of the *nerve cell bodies* are collected together in segmentally arranged masses or *ganglia*. The points of contact between individual neurons are called *synapses*, the junction generally formed by multiple points of contact. Many axon collaterals terminate in *end knobs*, swellings which are applied to the surface both of the dendrites and of the cell bodies of other neurons.

Conduction of excitation through synapses has characteristics different from conduction through nerve trunks composed of axons. According to Cajal and Van Gehuchten, normal conduction is always *cellulipetal* in *dendrites* and *cellulifugal* in *axons*.

Nerves are divided into three different groups: nerves containing nerve fibres which conduct centripetally (i.e., from the periphery of the body to the central organs, brains and spinal marrow), *sensory nerves*; nerves containing centrifugally conducting nerve fibres, *motor nerves*, which stimulate the muscles, etc.; nerve trunks containing both types of nerves, *mixed nerves*; Motor and sensory nerve fibres can conduct in either direction, along axons, but when the path of conduction involves a synapse the passage is invariably unidirectional, i.e., from axon collateral to dendrite or cell body, never in the opposite direction.

We have observed that nerves terminate or start with end knobs The motor nerves terminate with special muscular bodies at the sarcolemma of muscular fibres (see p. 156); the sensory nerves terminate in the skin with different bodies (see fig. 22) known as the *touch discs of* Merkel and the *bodies of* Wagner-Meisner, both used for sensorial observation; the *bodies of* Vater-Pacini (for registering pressure); the *bodies of* Grandry; *of* Herbst; the *end bulbs of* Krause (for registering low temperature) and *of* Ruffini (for registering heat and pressure); Golgi-Mazzoni *endings* (subserving pressure). Woollard (Bibl No. 411) studied the level at which different sensations are created in the skin of the underarm (see fig. 22). He found that pressure bodies occur at 2.0-2.5 mm depth, heat bodies at 1.75-2.5 mm, general feeling at 0-2.0 mm, cold at 1.0-1.5 mm, intensive pain at 1.0 mm and superficial pain at 0.25-0.5 mm depth below the surface of the skin. The minimum distance of excitation that creates two separate sensations of pain amounts to 1 cm on the underarm, $^1/_2$ cm on the palmar surface of the hand and less than $^1/_2$ cm on the finger tips.

The nerves unite towards the central nerve organ in the body into larger bundles. Two main centres of nerve control occur in the animal body:

1. the *animal* or *central nervous system*, the organ regulating our physic processes and conducting consciously perceived phenomena such as movement, feeling, etc. It is composed of *brains*, *spinal marrow* and *nerves* connecting these central parts with the different organs;

2. the *sympathetic*, *vasomotoric* or *visceral nervous system* is composed of two strings, the *peripheral ganglia*, situated on both sides of the spinal column, the ganglia of each chain being connected by longitudinal fibres. The lateral ganglia send post-ganglionic fibres to the spinal nerves, which convey sympathetic post-ganglionic fibres to the blood vessels of the skin and skeletal muscles, to the sweat glands and to the smooth muscles (see p. 156) of the hairs. The axons of

the neurons which receive the impulses lie entirely outside the central nervous system. The sympathetic system, contrary to the central nervous system, does not seem to be controlled by normal will-power; it regulates the innervation of the heart muscles and it controls the vasoconstrictor and vasodilator fibres of the blood vessels, dilation of the pupils, secretion of glands, metabolic processes, etc. The sympathetic system is considerably influenced by a part of the brain stem, called *hypothalamus* (see p. 131 and 396).

The nerves of the central nervous system are divided into *brain nerves* (12) and *spinal marrow-nerves* (in man 31 pairs: 8 jugular-nerves, 12 chest-nerves, 5 lumbar-nerves, 5 sacrum-nerves and 1 tail-bone nerve).

Human *brains* are a soft, partly grey, partly white mass of cells weighing about 1,300-1,500 g for an adult male, for an average female abt. 125 g less. Its chemical composition is very complicated: the grey parts contain abt. 85% water (the white parts 69%) and abt. 0.5% mineral salts (mainly potassium). Several proteins occur, of which the

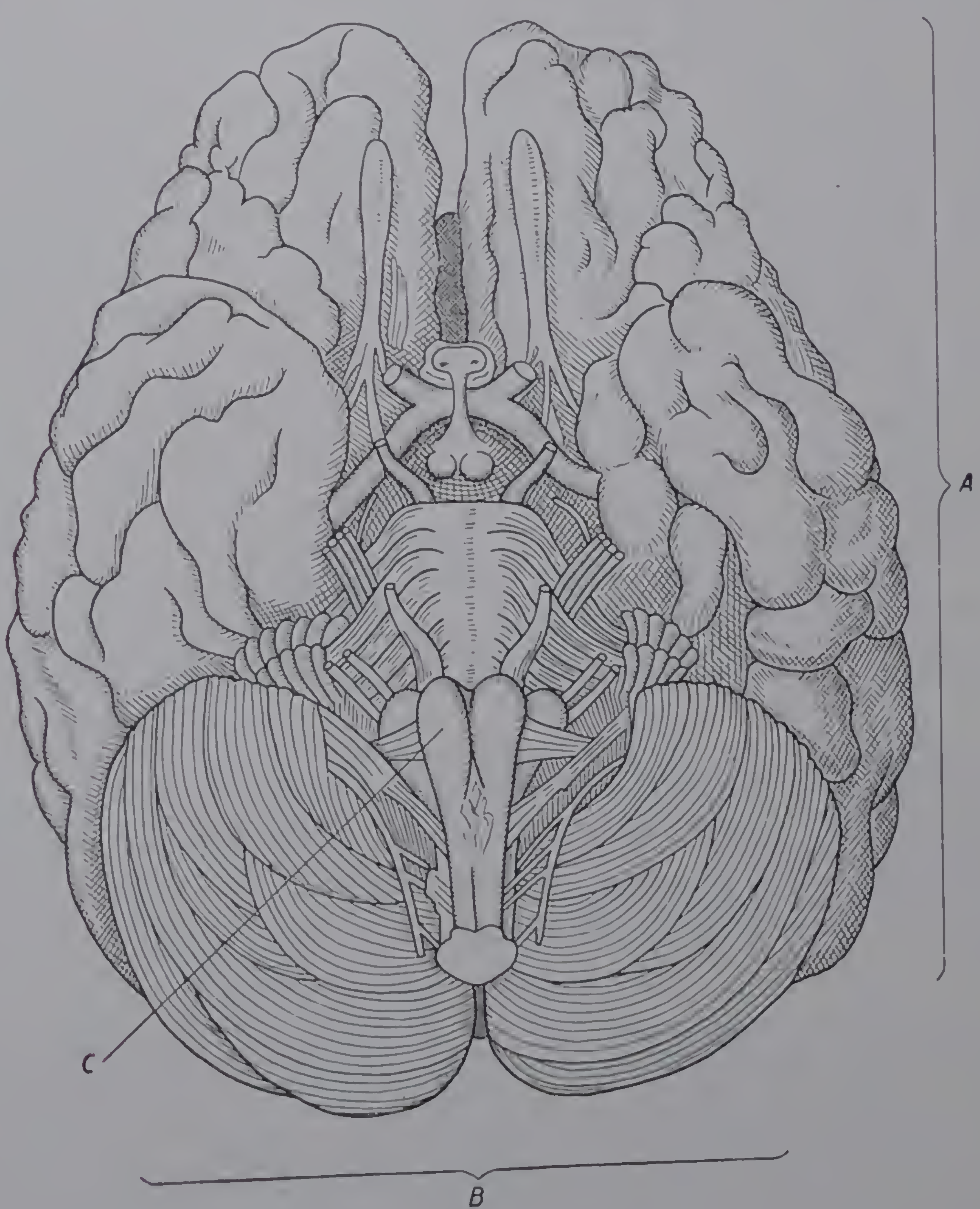


Fig. 9: (Ch. Bles: Populair Geneeskundige Encyclopaedie, p. 817) A = cerebrum, B = cerebellum and C = medulla oblongata.

most important is *protagon*, a phosphorus containing protein (a mixture of *lecithins*, a substance prominent in the nerve tissues, blood corpuscles, etc.).

Formula of lecithin:

$$\begin{array}{l} CH_2OCOR \\ | \\ CHOCOR \\ | \\ CH_2OPO(OH)OCH_2CH_2N.Me_3.OH \end{array}$$

Brains are divided into two main parts: the cerebrum and the cerebellum (see fig. 9):

The *cerebrum* comprises seven-eighths of the total brains. Seen from above the skull covers the other parts and is separated by a deep groove into two parts the *hemispheres*, the outer layer of which is composed of grey matter, and the *cerebral cortex*, the centre part of which is white and composed of a group of *nuclei*. The surface is made up of a great number of windings, the *gyri*, separated by deep grooves, the *sulci*. Each hemisphere consists of three parts (from the front to the rear): the frontal lobes, *lobus frontalis*, the central part, *lobus parietalis* (lobes of the skull) and *lobus temporalis* (lobe of the sleeping centre), and the rear lobes, *lobus occipitalis*.

At the bottom of the groove separating both hemispheres is the *brain stem* (corpus callosum) which connects both hemispheres. In contains in the posterior part the *thalamus*, the great sensory ganglion which receives and forwards all sensory impulses destined for the cerebral cortex. At the base of the diencephalon, below the thalamus lies the *hypothalamus* (see p. 396). On p. 146 we discuss the electric field of the brain and we indicate the great importance of the thalamus for all psychic processes and therefore including divining phenomena.

Studies in recent years by WALTER (Bibl. No. 410) and FULTON (Bibl. No. 392) have revealed that the final synaptic junction and relay station for the transmission of corticipetal impulses lies in this portion of the brains. It has been found that fibres from any one cortical area end in the same thalamic nucleus which projects to that area.

The thalamus is not a homogeneous unit. It is a paired structure, each half of which is made up of at least three functionally distinct groups of nuclei; these doublets play different roles in the integration of different impulses and sensation. On each side the thalamus receives six projections: Two (the optic tract and lateral lemniscus) carry the impulses concerned in vision and audition (see p. 113 and 108); the other four are the tracts from the spinal cord, medulla oblongata (see p. 132) and cerebellum.

WALTER gives the following names to these main groups of thalamic nuclei:

1. *Nuclei with subcortical connections only:* They do not degenerate if the cortex is removed; they have no direct cortical projections and seem to have some relation with *visceral sensibility*.
2. *Cortical relay nuclei:* They receive fibres from primary and secondary sensory neurons and project to the cerebral cortex; after removal of the cortex they degenerate. They are divided in the *anterior nuclei, ventral nuclei* (*lateroventral-* and *posteroventral resp.*) and the *geniculate bodies* (lateral and medial resp.).

a. The *lateroventral nucleus* projects to the precentral motor areas (see fig. 10, page 196) of the cerebral cortex; it relays impulses from the dentate nucleus of the cerebellum to parts of the cortex which *regulate muscular movements and tone* (see fig. 13).

b. The *posteroventral nucleus* projects to the post-central gyrus or sensory

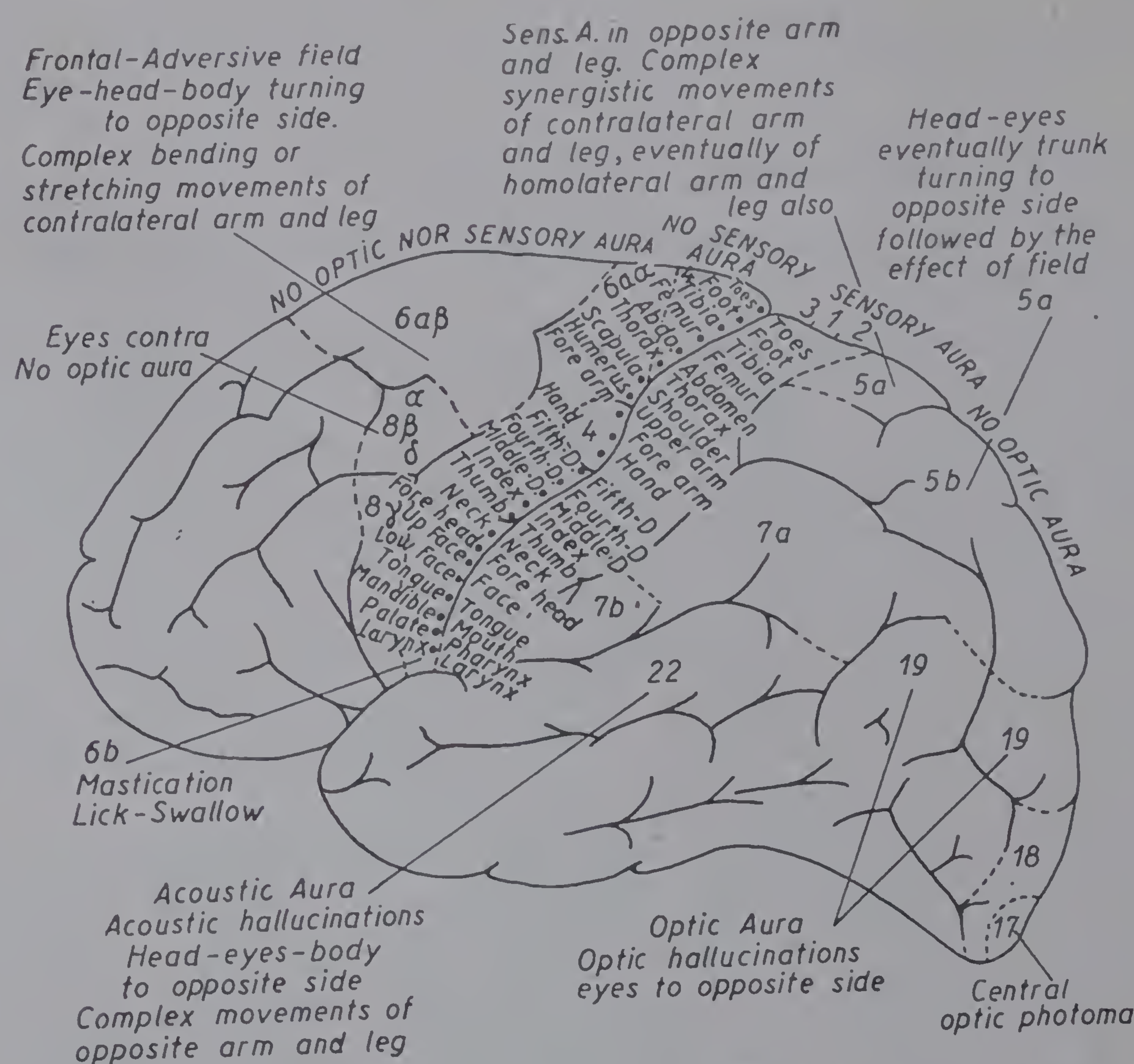


Fig. 10: (Bibl. No. 337) Diagram of human cerebral hemisphere seen from the left side and illustrating areas the electrical stimulation of which is followed by movements or sensation (after FOERSTER AND PENFIELD).

cortex (see p. 123, fig. 10) to which they relay impulses *giving rise* to at least 5 modalities of *somatic sensation* (see fig. 12): postural recognition and appreciation of passive movements, tactile localization, tactile recognition of differences in weight of a test object, spatial discrimination and the appreciation of the size, shape and form in three dimensions (stereognosis) and recognition of differences and similarities in temperature.
Clinical studies of cortical lesions have shown that motor and somatic sensory area are completely separated in the cortex (see fig. 10 and 11).

c. The *lateral geniculate body* is a relay station for *visual impulses*.

d. The *medial geniculate body* mediates *auditory impulses*.

3. *Association nuclei:* They project to the association areas of the cerebral cortex and degenerate when these parts of the cortex are removed. *They probably serve higher sensory functions.*

The second important part of the brains is the cerebellum.

The *cerebellum* is situated in the rear of the skull below the cerebrum and is divided into two hemispheres, connected by the *pons varoli*, each half being concerned with adjustments of tone and movement in the corresponding half of the body.

The continuation of the spinal cord in the skull is called *medulla*

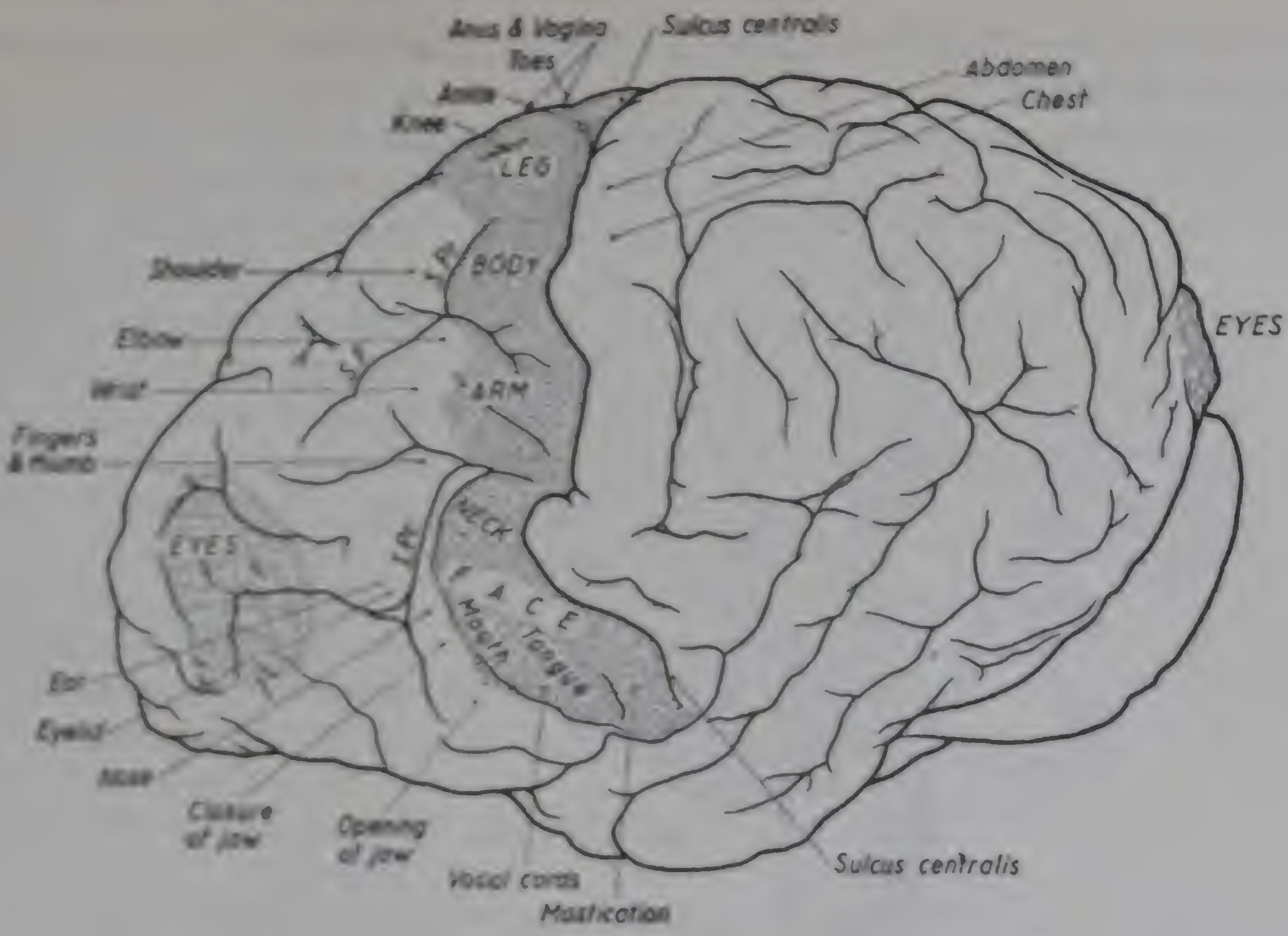


Fig. 11: (Bibl. No. 337) Outer aspects of the brain of the chimpanzee, showing the position of the motor cortex. Electric stimulation at the parts indicated causes movements of the corresponding muscle groups (after SHERRINGTON).

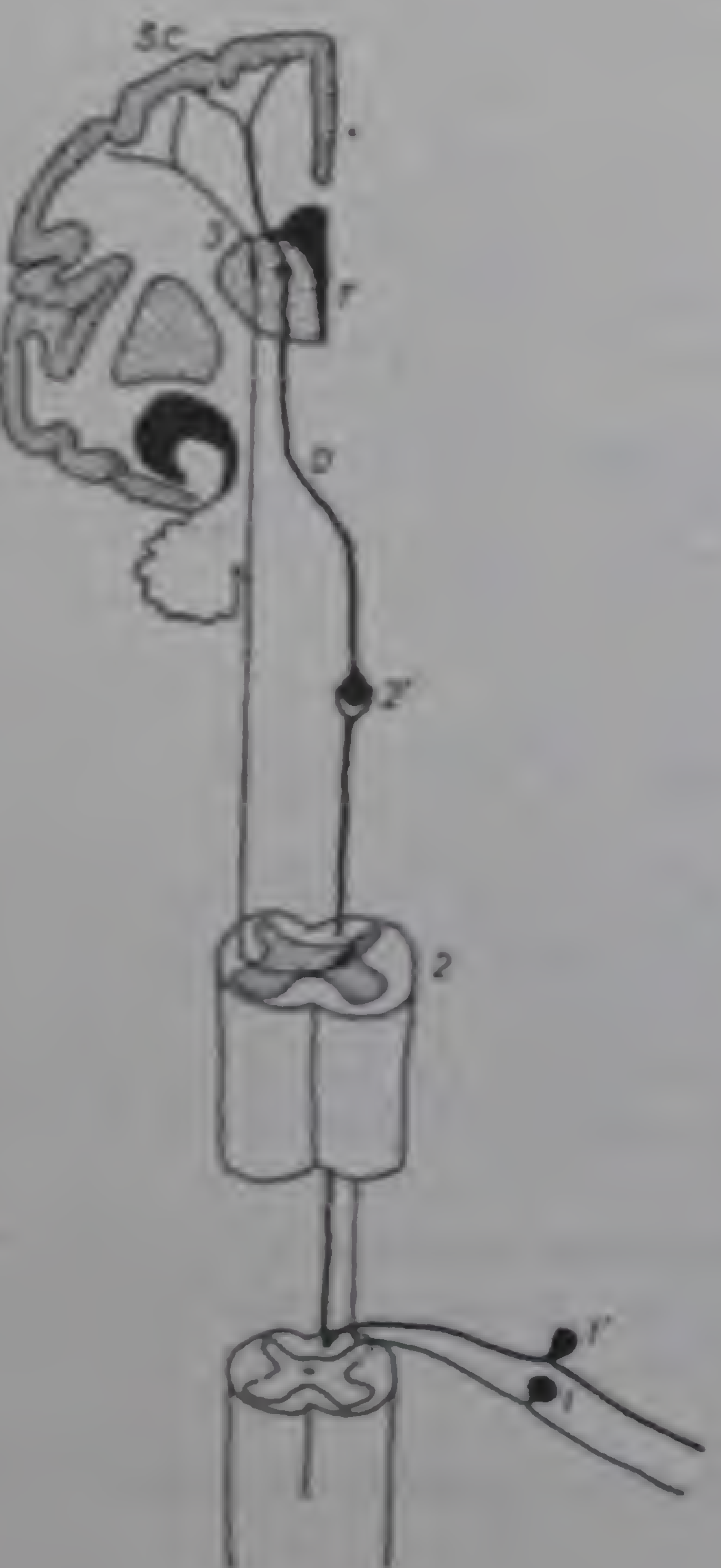


Fig. 12: (Bibl. No. 541a, fig. 127) Diagram of the sensory paths. S.C. = sensory cortex; T = thalamus; D = decussation; 1, 2 and 3 = cell stations on the course of tactile pathway; 1′, 2′ = cell stations on the course of deep sensibility path.

oblongata and is partly surrounded by the cerebellum and is covered by the cerebrum.

The brains and spinal marrow are surrounded by three membranes, the *dura mater*, *arachnoidea* (a very thin membrane) and the *pia mater* (soft membrane which follows all the irregularities of the brains); the blood circulation in the brain is governed by four arteries.

This short summary of the main structural elements of the nerve cell and the nerve systems in the animal body facilitates the reading of the following chapters for non-medical readers.

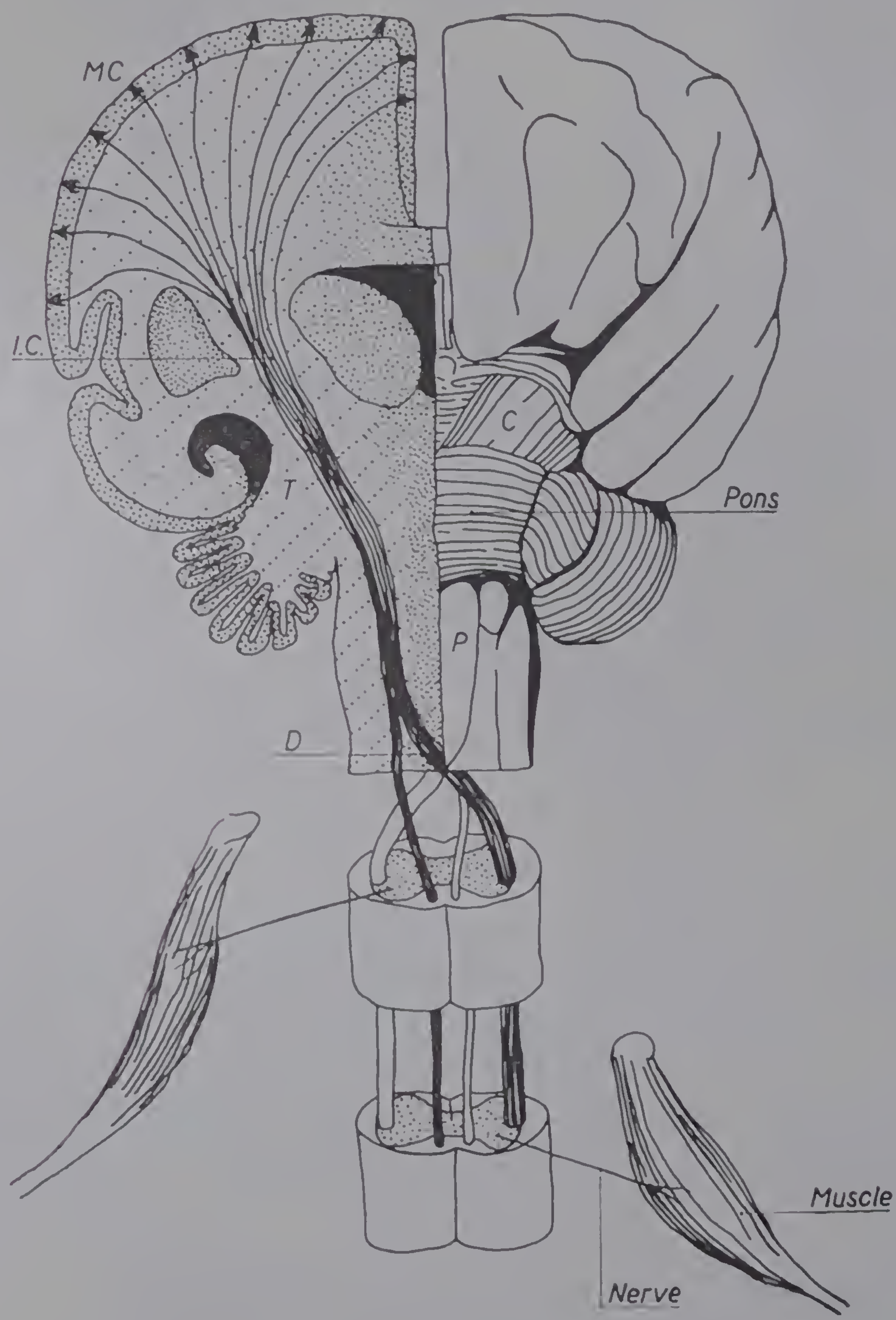


Fig. 13: (Bibl. No. 541a, fig. 125) Diagram of the motor pathway seen in diagramatic section of right side of brain. M.C. = motor cortex; I.C. = Internal capsule; T = motor tract below the internal capsule; D = decussation; C = crus cerebri; P = pyramid on undissected side of brain.

2. B. 2. Law of constancy of nerve cells

It is generally known that the cells of the body continuously die and are replaced by others; in other words a rejuvenation is always taking place (the 25000 milliard red blood corpuscles, i.e., 5 000000 per mm^3 in the human body are completely replaced over a period of several weeks by the action of the bone-marrow). The speed of rejuvenation decreases with age.

There is one element in the body which is not rejuvenated, i.e., the nerve cells. The nerve cells of the central nerve system contain the impressions of all our experiences in life. If these cells are lost the person ages rapidly.

Experiments of Hartmann, Woodruff, Carrell a.o., with tissue

cultures in vitro, indicate that the non-differentiating cells are practically immortal so long as no poisonous substances are present in the surrounding fluid. However, the energetic processes in the brains are bound to create such poisonous chemical compounds and as a result the nerve cells eventually die. Death is therefore called by MÜHLMANN and others a "*brain death.*"

Although the nerve cells are rather permanent in character compared with the other cells, they possess a great elasticity in their capacity to adapt themselves. EWALD crossed the muscular nerves of the left and right wings of a pigeon. The bird was at first completely helpless, but after a short period could fly normally again. Similar experiments were carried out with great success by BETHE, who crossed the nerves of the left and right leg of a dog. During the process of ageing these regenerational capacities of the nerve cells seem to decrease in a manner similar to the generally known phenomenon of "material fatigue" after long, continuous elastic deformation by external forces.

2. B. 3. Laws of electrical excitation

A nerve is characterized by two phenomena, *excitation* and *propagation*, the latter being described as the transmission of excitation. Excitation is common to all living cells but is particularly developed in nerve and striated muscle.

We discussed on page 121 the magnetic excitation of nerves, but the most commonly used is an electric current. The most important laws governing electric excitation were compiled by COLE (Bibl. No. 387) in a graph and can be summarized as follows:

1. *The stimulating current must pass a certain length of time*, the *utilization time, to bring about stimulation*, in order to change the e. m. force at all phase boundaries, a process known as *polarization* of the nerve. If no response is elicited within a certain time after the initiation of the current there will be no response, regardless of the length of time the current is applied. The period between the moment of application of the current and the first response is called *latent period*. In the striated muscle of frogs it is only $0.2\text{-}0.3 \cdot 10^{-3}$ sec, depending on the intensity of the current. Alternating currents of exceedingly high frequency (100,000-1,000,000 c) — Tesla currents — do not cause any physiological stimulation even with the highest current intensity.
2. The *minimal duration of current necessary for stimulation decreases with increasing intensity of the current*. With lowered current intensity the time limit increases, thus the *strength-duration rule*. In other words, current pulses of short duration require greater intensity to reach the stimulation value. As a result very high currents can burn tissue without causing excitation.

3. *The intensity of the stimulating current should not be lowered beyond the threshold value*; very weak currents fail to stimulate, no matter how long they are allowed to pass. This minimal current is called rheobasic current or the *rheobase*. The minimal time for a stimulating current having twice the intensity of the rheobasic current is called the *chronaxie*, a time constant which proved to be a very important characteristic of excitability. It can be shown that threshold currents with a duration approximately equal to the chronaxie produces excitation with a minimum expenditure of energy and minimum injury to the tissue.

   According to ROSENBERG a.o., the rheobase for myelinated nerves in vitro is abt. 10^{-9} A, for unmeylinated nerve 10^{-6} - 10^{-7} A. To stimulate a muscle by the muscular bodies of the motor-nerve is required (see p. 141) an action current of 20 - 30 mV.

   According to SCHRIEVER (see Bibl. No. 407) the chronaxie of different sensory nerves is as follows;

   Tooth pain $0.06 \cdot 10^{-3}$ sec.

Sensation of pressure:	$0.18 - 0.21 \cdot 10^{-3}$
Intensive surface pain:	$0.45 - 0.49 \cdot 10^{-3}$
Depth pain:	$0.82 \cdot 10^{-3}$
Sensation of cold:	$1.67 - 1.74 \cdot 10^{-3}$
Sensation of light:	$2.34 \cdot 10^{-3}$
Sensation of taste:	$2.54 \cdot 10^{-3}$
Sensation of dizziness:	$3.60 \cdot 10^{-3}$

   It has been found that myelinated fibres conduct impulses at velocities much higher than those of the unmyelinated fiber. The action potentials as recorded across a single cell membrane of a giant axon show that starting from a rest-potential of 58 mV (outside positive) the action potential swings to 110 mV (outside negative).

4. *Since chronaxie and rheobase are independent of each other, irritability of any tissue can be defined only by at least 2 independent entities.* It has been found that elevation of temperature raises the sheobase and depresses the chronaxie.
5. *If the stimulus is strong enough to produce a response, the magnitude of the response is completely independent of the strength of the stimulus; this is called all-or-none-law.* This is true only for one simple nerve fibre. If a group of nerve fibres with different rheobase is stimulated, a maximal response will be seen only after the highest threshold value is surpassed.
6. *An electric current, however weak or brief its duration, leaves the nerve in an altered state of excitability for* a time after the current ceased to flow. The degree of alteration depends on the current intensity, time and direction of current.
7. *Summation of two brief sub-threshold cathodal shocks may give a response, if the time interval between the shocks is not too great, this is known as the law of summation of inadequate stimuli.* On page 98 we discussed a similar phenomenon with plants, known as the law of TALBOT.
8. *During the passage of a constant current the excitability is increased* (threshold decreased) *at the cathode and decreased at the anode*,

phenomena known as *catelectrotonus and anelectrotonus*. In other words a stimulus applied to a nerve changes the threshold value. If the anodal current is made strong enough, excitability may be lowered sufficiently to block the passage of a nerve impulse.

The actual rheobase of a nerve is the threshold strength of a cathodal current of long duration.

9. *The excitability at the cathode, after reaching a maximum, tends to return to its resting value*, a phenomenon known as accommodation.
10. Thus *by gradually increasing the current intensity, a strong current can be passed through the nerve without stimulation*. A gradual decrease is therefore not stimulating, only an abrupt discontinuation, hence the gradient in change of current intensity is important.
11. *The excitability curve for sinusoidal alternating current shows an optimum frequency for stimulation*, being 60 cycles/sec. At very high frequencies the threshold value is also very high. This phenomenon forms the basis of diathermy machines, electric cauterizers, etc.
12. *Effective stimulation is only obtained if the current passes the nerve-cell membrane*. An electric current can follow two courses: through the nerve membrane and protoplasm, or only through the protoplasm. It has been found that the second one only is effective.
13. According to Rosenblueth, *the excitability of nerves decreases after a stimulation lasting* 20-60 min.

The phenomena described under sub-parag. 3, 8 and 9 make it possible to differentiate 3 periods after excitation has taken place: the *absolute refractory period* (immediately after excitation the threshold value reaches infinity for a short period), followed by a period of raised threshold, the *relative refractory period*, after which the threshold falls below normal for the *supernormal period*.

We have seen that the least damage to tissue is caused with current pulses having durations of approximately a chronaxie and with alternating currents having the optimal frequency. The degree of response depends on the amount of energy reaching each nerve fibre. Tissue cells are immersed in a medium which is usually a good conductor (see p. 142). If the excitable tissue is buried deep in other tissue, the effective fraction of the current may be very small.

In 1926 Dowing, Gerard, and Hill (Bibl. No. 395) demonstrated *a rise in the temperature of the nerve during activity*.

The average heat production of a resting frog's nerve in oxygen at 20° C is abt. $70 \cdot 10^{-6}$ cal per gram per second, according to Beresina (Bibl. No. 384 a). Feng and Hill (Bibl. No. 390 a) found that the greatest rate of total heat production, in excess of the basal, in response to steady stimulation is not more than $40 \cdot 10^{-6}$ cal per gram/sec.

According to Gerard the total heat per cm of simple fibre per simple impulse is of the order of 10^{-12} calories. Feng and Hill (Bibl. No. 390 a) demonstrated that when a nerve is stimulated at a frequency below 50 shocks per second the rate of heat production rises; in 25 to 40 min it becomes constant and a steady state may then be maintained almost indefinitely. At higher frequencies a steady state is impossible; the heat rises quickly to a maximum and then falls off until in a few minutes it is a small fraction of its max. value. If the frequency is suddenly reduced, the heat

rate quickly rises again, indicating that "fatigue" in the ordinary sense has not occurred. The nerve heat can be divided into *initial* and *delayed heat* (see muscular heat, page 161). The ratio between both — 1 : 1.25 — is different from the muscle. Another difference is that in the nerve the whole of the delayed heat, not merely a fraction of it, occurs whether oxygen is present or not.

2. B. 4. Laws of chemical excitation

It has long been known that changes in the chemical composition of the fluid surrounding a nerve may drastically alter the response to electric stimulation.

1. It is well known that *oxygen* is very important in the metabolic processes of nerves, both during rest and activity;
   a. The *oxygenconsumption* of a frog's nerve at rest is abt. 42 $m.m^3$ per gram of nerve/hour; per hour of stimulation it is abt. 15 $m.m^3$ per gram of nerve.
   b. In *the absence of oxygen* a nerve very slowly loses its ability to conduct. Even after 8-10 hours anoxia readmittance of oxygen leads to prompt recovery.
2. The *carbon dioxide production* decreases, according to SCHMITT, when a frog's nerve is subjected to low frequency stimulation for short intervals, but increases when the frequency is increased above 10 per sec.
3. *Calcium* and *potassium ions* are particularly important in this respect. Small changes in their concentration cause profound changes in the nerve.
   a. A nerve treated with solutions containing increasing amounts of potassium shows first, according to FENN (Bibl. No. 391) and LEHMANN (Bibl. No. 402) increased excitability, but it later decreases and may reach zero. A decrease in potassium below normal tends to decrease the excitability.
   b. If a nerve is treated with a calcium-free solution the excitability increases and the accommodation decreases, so that several responses may be elicited with a simple electric shock. If treatment is continued the nerve may even burst into *spontaneous activity* and discharge impulses at rates of 300/sec or more for several minutes (exp. *of* BRINK *and* BRONK, Bibl. No. 386). Increase in calcium reduces the excitability.
4. *High values of* p*H* might create spontaneous activity, according to LEHMANN (Bibl. No. 401). This was attributed to suppression of the ionization of calcium rather than to a direct hydrogen-ion effect.
5. TROTSENBURG (Bibl. No. 409) noticed that narcotics such as chloroform, ether, alcohol, etc., are non-conductive for weak electric currents. The influence of similar substances on the nerves probably depends on the permeability of the membranes surrounding and insulating the nerve cells. Local insensibility in nerves or

muscles might be created by local decrease in electric conductivity of the nerves.

This short review indicates sufficiently that conditions affecting the ionic balance of blood may produce profound changes in the nervous system. The phenomena discussed in previous chapters of the influence of volatile components on colloidal substances, particularly on living matter (see p. 32-54), the different processes discussed in the sections on the sense of smell (page 102) and taste (page 105) and finally the peculiar processes of sweat secretion through our skin, indicate that external chemical substances can drastically change the electric stimulation processes in the peripheral nerves in the skin and nose and in the central nervous system as a whole.

2. B. 5. Mechanism of nerve conduction

The manner in which a nerve transmits its impulse was explained for the first time by CREMER in 1899. His *core-conductor theory* or *membrane hypothesis* has been accepted by most physiologists since 1936, as recent experiments confirm the correctness of CREMER's theory. According to this hypothesis the nerve-cell-membrane is the seat of an emf. of 50-100 mV (see p. 17) which keeps the protoplasm of the cell near the membrane electrically negative with respect to the intercellular fluid. Since all points on the resting cell membrane are at the same potential, there can be no current flow and no electric activity. If, however, there is a membrane breakdown at one point, the potential will not be the same at all points and since there is a conducting medium, a current will flow from the normal parts of the axon into the region of breakdown. These local currents serve as stimuli for the breakdown of adjacent parts of the fibre and the breakdown thus spreads along the axon like a flame along a fuse. The difference with a fuse is: the nerve segment broken down immediately repairs itself in readiness for the next impulse and the propagation can therefore be better compared with the propagation of an oscillatory wave movement, for example in water. Through the work of LILLY (Bibl. No. 403-405) the mechanism of travelling waves is now better understood. To produce travelling waves of electric polarization, a system consisting of 2 phases (any metal and salt) is insufficient; a third phase must be interposed between the two and this must be unstable yet capable of regeneration. LILLY succeeded in finding such a model in the inorganic world. He discovered that a film of iron oxide on an iron wire possesses such properties.

Iron in concentrated HNO_3 fails to dissolve and becomes covered with a thin invisible film of oxide. This "passive" iron behaves similarly to a highly electro-positive noble metal in a voltacell. In strong HNO_3 this condition is maintained indefinitely. Dilute HNO_3 (sp. gr. 35%) dissolves steel wire rapidly but fails to dissolve steel rendered passive by previous immersion in a strong acid. However, if the oxide film is broken at one place the lesion extends over the entire surface and all the iron is dissolved. In solutions of 40-65% (sp. gr.) this reaction is temporary and the metal returns spontaneously to the passive condition.

If a passive steel wire suspended in such a solution of HNO_3 (40 - 65%) is touched at one end with ordinary active Fe or Zn, the film nearby will be broken first. The lesion becomes visible by darkening of the formerly bright metallic surface and by effervescence, H_2 being developed. The lesion rapidly repairs itself and the local effervescence disappears. But almost immediately the neighbouring portions of the wire show the same phenomena (discoloration and effervescence), which in turn reverts to the passive state and so on. In other words a wave of temporary activation is transmitted over the surface of a passive steel wire, similar to the propagation of a nerve impulse.

LILLIE *demonstrated that this wave phenomenon in the steel wire can be created chemically* (by touching with zinc), *mechanically* (by bending the wire or tapping it with a glass rod) and *electrically* (by a local electric circuit at one end of the wire, the impulse starting at the cathode as in a nerve). The velocity of propagation varies between cm and metres per sec, depending on the type of wire used. The character, intensity and duration of the reaction are independent of the activating agent; in other words the *all-or-none-law can be applied on inorganic processes.* A steel wire also exhibits *electrotonus.* Cathodic polarization facilitates transmission of the waves, the threshold of electric excitability being lowered; anodic polarization has the opposite effect.

It has not yet been possible to explain the greater propagation speed of myelinated fibres compared with unmyelinated fibres. One theory explains the difference with the nodes of RANVIER. In the myelinated fibre the impulse is forced to jump from node to node (as at those places the myelin is missing) without causing excitation of the intervening portion of the axon and can thus travel fasfer. Another theory assumes a lowering of the reaction capacity of the membrane resulting from the covering myelin.

So far we have discussed the mechanism of the propagation of an impulse only from a general point of view. In order to understand the deeper causes of nerve impulses it is necessary to study these problems in greater detail.

According to GENGERELLI and HOLTER (Bibl. No. 383), the nerve axon can be compared with a cylinder with a porous surface through which pass ions of positive sign. The ions of the opposite sign remain on the inner side of the surface and this process of diffusion is said to continue until equilibrium is reached. The result is a cylindrical double layer of charge separated by a semi-permeable membrane. Stimulation is viewed as a breakdown of this equilibrium state with a resultant shuffling of the charges at the point where the stimulus is applied. This state of ionic chaos moves down the axone as a zone of depolarization and constitutes the nerve impulse.

B. J. KRIJGSMAN (Bibl. No. 399) extended this ionic theory and gave an excellent review of the different theories. His final conclusions can be summarized as follows:

According to BERNSTEIN (1912), the nerve fibre is surrounded by a selecting membrane permeable for small cations and impermeable

to the large anions. This creates a positive charge on the outer part of the membrane and a negative charge inside. According to R.S. BEAR and F. O. SCHMITT (1939), the cations are composed mainly of potassium ions (the nerve plasm contains 20 times more K ions than blood) and the anions mainly of amino acids. The diffusion of the ions, together with the energy released during oxidizing processes in the nerve fibres create membrane potentials up to 100 mV. If the thickness of the membrane were to be 100 A.U. (= 10^{-6} cm = thickness of 2 lipoid molecules) the field strength would then amount to 100000 V/cM. Because of the polar construction of the molecules, they are directed in strips parallel to the lines of force (see p. 53). If the distance between these strips (space lattices) is smaller than the anions the latter cannot pass through. However, an external stimulus might decrease the surface charge and field strength in the membrane and cause an increase in the distance between the molecule-strips, allowing the anions to pass through and neutralize the cations. This process considerably decreases the electric resistance of the membrane; according to L. S. COLE and H. J. CURTIS, 1939, the resistance might drop from 1,000 to 25 Ohm/cm.

We have discussed only the processes of propagation of impulses in the nerves themselves. We have seen that the nerve collaterals terminate with end-plates. The transmission of excitation at the junction of these collateral terminates of motor nerves and the sarcolemma of the muscle fibre, the *neuromyal junction*, requires special attention.

The substance of the muscle fibre at the region of the nerve endings, is specialized by a mass of granular protoplasm in which are embedded many muscle cell nuclei. This nucleated region is the *motor end-plate* and it is here that the nerve impulse sets up a propagated disturbance in the muscle fibre.

The actual process of impulse transmission is not known with certainty. The same hold for the transmission through *synapses* between individual neurons. Both processes of transmission are similar in that conduction is invariable unidirectional (see p. 129). In other words a nerve fibre can stimulate a muscle fibre, but not vice versa; and conduction at the synapses takes place only from the axon collateral to the dendrites and cell body of another neuron. It has been found that this neuromyal transmission creates a slight delay, the *end-plate delay*. The time between the arrival of the nerve impulse at the motor end-plate and the beginning of the disturbance in the muscle fibre of frogs is abt. $2 \cdot 10^{-3}$ sec. Whereas the motor nerve can be stimulated with 3 mV, according to SCHAEFER (Bibl. No. 407), the transmission energy required at the neuro-myal-junction for stimulating a muscle is 20-30 mV.

The mechanism of neuro-myal junction is explained by two rival theories:

1. *Chemical theory of* DALE (1934) (Bil. No. 389a): The discovery that nerve fibres, which control the activities of glands, cardiac muscles, etc., act through liberation of specific chemical mediators, such

as *acetylcholine*, an active ester of choline, $CH_2(OH)CH_2N(CH_3)_3OH$ and *sympathin* and the elicitation of discharges over neurons by perfusing low concentrations of acetylcholine through a ganglion, etc., suggest that synaptic impulses liberate small amounts of acetylcholine in the ganglion; this in turn excites the ganglionic neurons. Studies by Bronk a.o., have shown that potassium and calcium ions modify the discharges produced by acetylcholine. The activity of the latter is greatly modified by ionic changes in the environment of the ganglia. It has been found that acetylcholine is rapidly destroyed by an enzyme, *cholinesterase*, present in all tissues and in blood. This hydrolysis is prevented or diminished by *eserine* (Physostigmine). A local concentration of esterase occurs at the neuromyal junction; this action destroys the acetylcholine liberated at the nerve endings during the *refractory period* (see p. 137) (according to Marnay and Nachmansohn the concentration of esterase at the nerve terminals exceeds by several thousand times that in the bulk of the muscle).

2. *Electric theory of* Hermann (1879) and emphazised in more recent years by Lapicque (Bibl. No. 400), Lilly and others: According to this viewpoint the muscle fibre is stimulated by the local flow of the action current which is created at the termination of the nerve.

Both theories should probably be combined in order to explain the whole process of synaptic or neuromyal transmission.

2. B. 6. Influence of the medium surrounding the nerve membrane

During the discussion of the laws of chemical stimulation we mentioned several influences of the medium surrounding a nerve on the nerve conduction. A conducting nerve with an insulated outer layer covered by a conducting intercellular fluid can be compared with an electric condenser.

1. Hodgkin (Bibl. No. 396) could prove that the speed of propagation in a nerve depends upon the *electric resistance of the medium* outside the nerve fibre. The smaller the resistance (the greater the conductivity) the greater the speed.
   In isolated crab fibre it was 14-40% faster if the fibre was surrounded with seawater than if oil were used; in giant axons it was sometimes 80-140% faster.
2. Lilly (Bibl. No. 403-405) could demonstrate that the velocity of propagation is altered considerably by changing the volume of the fluid outside the nerve.

This summary of the enormous literature on nerve action had to be given, especially for the non-medical natural scientist, as the processes of nerve action form the basis of all biological processes in the living body and therefore of the divining phenomena. We have not yet discussed the electric fields in the centres of nerve control, i.e., the brains.

C. The brains
(see Bibl. No. 412-504)

2. C. 1. Main structural elements of the brain

A short review of the main structural elements of the brain is given on pages 130-134.

2. C. 2. Centres of nerve impulses

In 1874, Caton, an English physiologist, was able to register with a galvanometer variations in the electric potentials of the cerebral cortex of rabbits and monkeys. This discovery was followed by new experiments by Gotch and Horsley (1889), A. Beck (1890), Danilewsky (1892), Cybulski (1892) a.o. With this encouragement, Berger, Professor at the Jena university, in 1902 started on his experiments with a capillary electrometer of Lippmann. The first results with dogs and cats were rather discouraging and he almost gave up further research. New experiments by Tschirjew (1904), Kaufmann (1912), Prawdicz and Neminski (1913) and Cybulski (1919) inspired Berger to such an extent that he began all over again.

On July 6th, 1924, during an experiment with a 17-year-old boy, Berger obtained the first definite evidence that brain actions are accompanied by variations in *electric potentials* of the cerebral cortex *which are neither caused by ordinary muscular action currents in the skull, nor by the blood stream in the human body or the influence of variations in blood circulation in the human brain created by variations in the respiration.* The instrument used by Berger was a string galvanometer of Edelman.

Berger kept his results secret up to 1929. Meanwhile (in 1925), a book was published by two Polish scientists Prawdicz and Neminski on their experiments with dogs. The recorded variations in electric potentials of the cerebral cortex of those animals were described as *electro-cerebrograms*. Two kinds of electro-magnetic vibrations were discovered: one group of 10-15 vibrations per second and one of 20-32 vibrations per second.

About 1930 Berger published several of his experiments on these so-called *electren-kephalograms* (E.K.G.) and has been considered since as the founder of modern electro-encephalography.

The name of these recorded diagrams was changed later by other scientistst into *electro-encephalograms* (E.E.G.). Davis introduced the name *cortical-electrogram*, on the assumption that the potentials arise mainly in the cerebral cortex. This name however has not been accepted by other scientists.

The experiments of Berger were tested in Italy in about 1936 in the Laboratorio di Psicologia Spermentale in Milan under directorship, first of Dr Rohracher, and later of Prof. Gemelli a.o. Several physiological laboratories in the U.S.A. concentrated on the same problems and confirmed the results of Berger (Rubin, Gibbs, Jasper, Andrews, a.o.). In England the experiments were confirmed by Adrian and Matthews;

in Holland by VAN DER HORST, TEN CATE, BARNHOORN, DE SMET, FRANKE, KOOPMAN, a.o.; KOOPMAN used a SIEMENS-electrocardiograph with a special front-amplifier.

Method of measurement:

The electrical potentials in the brain were measured originally by placing two silver electrodes in the surface skin of the head of the trial person (see fig. 14). At present the electrodes can be placed on the skin; this excludes a painful operation. The potentials of 2-1,000 microvolts, were at one time recorded with a string galvanometer of EINTHOVEN, using a front amplifier, but the cathode ray oscillograph is now mainly used. As both instruments are mentioned several times in the following chapters and as some readers may not be fully acquainted with these instruments, a short summary is given of the principles on which these instruments work.

Fig. 14: (Bibl. No. 431, p. 181) Position (a and b) of electrodes on the skull used by BERGER during his first measurement of electro-encephalograms.

The *string galvanometer of* EINTHOVEN (invented by EINTHOVEN in 1903 and constructed by DE GROOT) consists of a powerful electro-magnet between the poles of which is suspended a very fine wire of silver-coated quartz thread. To this thread the electric contacts are wired and any current passing through the wire causes it to move across the magnetic field. The wire is illuminated by a lamp and optical condensor and its image is enlarged by a microscope and thrown into a camera on which its movements appear as lateral movements of the string's shadow. By an appropriate horizontal cylindrical lens this vertical shadow is reduced to a spot that moves horizontally across the photographic paper. The paper in turn is moved vertically by a motor. In this way a graphic record of the potential changes is obtained, which shows the time on the abscissa scala and electric potentials in millivolts on the ordinates. The sensitivity of the string can be regulated and the excursions of the black spot varied in such a manner that either a vertical movement on the photographic paper of 1 cm represents a potential change of 1 millivolt or only 1 mm represents the same variations. Fig. 15 represents such digrams which were originally used by EINTHOVEN only for registration of the electric potentials created by the heart contraction. For this purpose two non-polarizable metal electrodes are connected both to the instrument and to two metal grips placed on the left and right-hand pulse of the trial person, the contact with the skin being improved by placing a paste of pumice

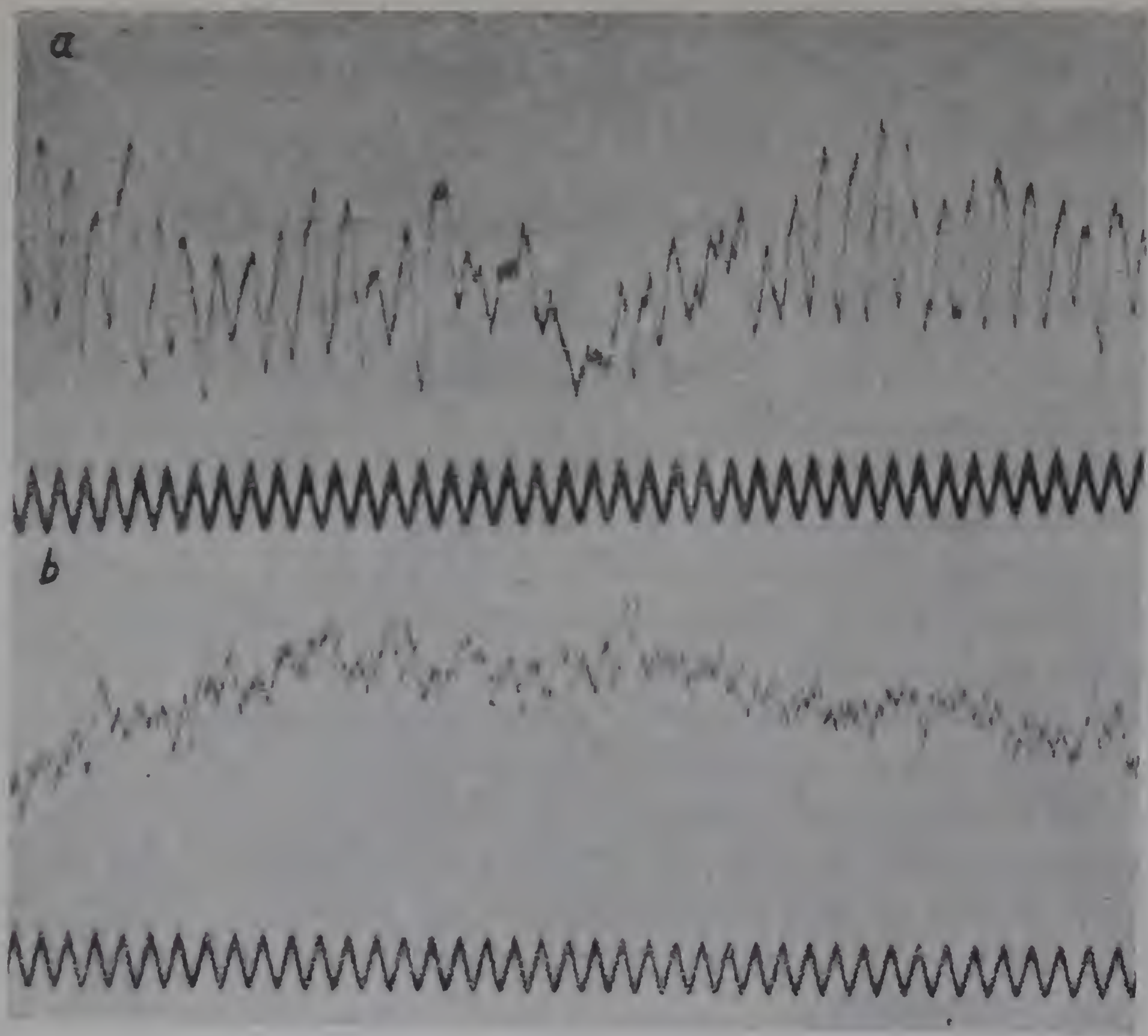


Fig. 15: (Bibl. No. 431, p. 210) Electro-encephalogram of a 9-year-old boy; in diagram a) the eyes of the boy are closed, the α waves are very clear; diagram b) immediately after the eyes are opened in a semi-dark room, the α waves being replaced by β waves.

and salt between the skin and the metal grips; this lowers the skin resistance to abt. 1,000 Ohm.

The *cathode ray oscillograph* is an extremely sensitive instrument, which can register variations of 1 mV on a screen with a light-ray spot which oscillates with amplitudes up to 70 cm or more. The instrument is based on the following principle: an electron source produces an electron beam which passes between two plates. The beam is brought to a focus at some point on a fluorescent screen and can be viewed or photographed as a spot of light. As soon as potential differences are created in the two plates surrounding the beam, it causes a shift of the electron beam and of the light spot on the screen.

Location of the electric potentials:

Berger assumed that the electric potentials of the encephalograms were caused by the *cerebral cortex* (see p. 131). Adrian assumed that the *occipetal part of the cortex* was the main source of the electric potentials. The α waves (see further) would be the result of the undisturbed action of the occipetal part of the cortex. Ten Cate, Walter, v. d. Horst and Koopman could prove, however, that after removal of the whole occipetal part of the cerebral cortex of animals no change in the α rythm was observed.

Further experiments have shown that the cerebral cortex is only one source of α waves. Other sources are the *thalamus* which has been discussed at length on p. 131-132

2. C. 3. Electro-encephalograms

Types of diagrams:

The E.E.G.'s (see Fig. 15) show different types of vibrations, which have been divided as follows:
α oscillations: slow vibrations of BERGER with a vibration number of 8-12 vibrations/sec. They change under different conditions and might disappear completely. They are usually most prominent when the subject is sitting or lying down quietly with eyes closed and mind at ease. Any considerable mental effort tends to depress them and intense concentration or emotional excitement causes their complete disappearance. In light sleep the α waves tend to become slower, larger and less regular in form and frequency. In deep sleep they are usually absent, although irregular groups of slow, large waves may occur at intervals. v. D. HORST described α waves as *an expression of psychic passivity*. Studies by HENRY (Bibl. No. 460) on the types of encephalograms of normal children revealed the following:

"The data pertaining to alpha frequency show strong evidence of sex differences, in that females tend to have faster alpha frequencies than males. There is also evidence that the low voltage fast type of record is more common among females. No consistent changes were observed to accompany the presumed onset of puberty in the 40 cases in which such a correlation was sought."

GIBBS (Bibl. No. 457, p. 42) has given a schema representing the average prominence of different α frequencies at different ages for different individuals. GIBBS used three types of measurements: either two electrodes are placed high on the forehead, one above each eye (*frontal electrodes*) or two more electrodes are placed in the parietal area, two or three cm from the midline and directly above the external auditory meatus (*parietal electrodes*); two electrodes might also be placed in the occipetal area (*occipetal electrodes*).

The 1-3 *frequency* per second in all three cases is mainly restricted to the age period 1-3 years (it disappears after the age of 9). It is mainly developed during the first 30 days of age. *The* 4 - 6 *frequency* (with F.E. and O. electrodes) begins mainly at the age of 2, measured with P.E. at the age of 3 - 9 months. Its prominence decreases gradually, but between the age of 13 and 16 (in case of F.E. and P.E.) it is suddenly prominent again, after which age it rapidly disappears.

The 7 - 8 *frequency* is mainly developed between the ages of 2 and 8.
The 9 *frequency* is mainly restricted to the ages of 4 - 16.
The 10 *frequency* is common after the age of 4.
The 11 *frequency* is common after the age of 9 (begins at the age of 4).

β oscillations: fast vibration of BERGER with a vibration number of more than 20 vibrations/sec. They are found in practically all circumstances and seem to increase in amplitude during *psychic activity*; if the function of the cerebral cortex is disturbed they either diminish or disappear completely.

Vibrations higher than 30 have been sometimes indicated as γ *oscillations.*

δ *oscillations*: very slow vibrations with a vibration number of 4 - 5 vibrations/sec. They originate mainly if the normal function of the cerebral cortex is disturbed.

L. J. KOOPMAN correctly pointed out "that these vibrations should not be designated as different kinds of vibrations, they serve exclusively to indicate certain definite frequency fields of one and the same kind of vibration, *relaxation vibrations*", which have to be split up into their components. KOOPMAN developed a mathematical system (Bibl. No. 475) based on the *analysis of* FOURIER, by which these different oscillations in the encephalograms are analysed and separated into fundamental tones and harmonies. As a result he discovered that frequencies much higher than those of the β or α oscillations are produced by the cerebral cortex.

Recently a mechanical analyser was constructed by the EDISON Swan Electric Co. Ltd., in collaboration with G. R. BALDOCK and W. G. WALTER (a British encephalographer) called an "electronic analyser." It can reach a conclusion in 10 seconds which would normally take several hours (see Bibl. No. 414 a).

Causes of diagrams:

The cause of the different types of brain waves have been studied by a great number of scientists. The problem can be reduced to the general *problem of synchronization of the electric potentials in the cortex of the cerebrum.* WALTER has given a clear analysis of this problem. If all cells were to create their electric potentials independently, the electro-encephalogram would be a straight line with only slight undulations. The same would happen if a completely synchronized discharge of all the cells were to take place at the same time along a bipolar circuit. The vibrations of the encephalograms indicate that a situation in between must occur.

ADRIAN made some interesting studies on the electric potentials created by the ganglia of the water beetle *dytiscus* during the respiration process, the neurons of the animal being almost as big as those of the vertebrata. The optic neurons of Dytiscus produce a rythmic activity of 7 - 10 oscillations/sec in case of a weak light reaction on the retina of the animal, of 20 - 30 oscillations/sec in case of strong exposure to light. The first type of oscillations is similar to the α waves of the E.E.G. diagrams when the trial person remains in a quiet dark room, a condition of psychic passivity. The other oscillations of Dytiscus correspond with the β rhythm.

The phenomenon that different neurons of dytiscus with almost the same rythm can discharge at the same time in larger groups is a process which WALTER *compared with the phenomenon of resonance.* This can be observed with two clocks, for example, of almost the same frequency, that gradually become synchronized.

PROSSER has shown that slow waves can be created as the result of many quick vibrations which take place in groups.

WALTER assumes that the α waves are the result of the discharge of many cells in the cortex, which vibrate each in a different, though very similar rhythm. The degree of synchronization and the number of neurons which discharge at the same time would determine the amplitude of the variations of electric potentials. The electric discharges create electro-magnetic waves which might activate other centres in the brain. A future analysis of this problem might reveal the existence of very penetrating Hertzian waves which, in certain favourable circumstances could stimulate simular waves in brain centres at a great distance (telepathic phenomena).

Influence of narcotics:

Experiments of KOOPMAN and FRANKE (Bibl. No. 451, 474 and 476) with the electro-encephalograph, on the function of the *thalamus* revealed the mechanism of different mental processes of paranormally gifted persons who are able to produce the divining phenomena discussed in chapter III.

1. If narcotics are applied, which have a specific stupefying influence on the cerebral cortex (such as ether, chloroform, morphine, scopal amine), a considerable decrease in the electric activity of the cortex can be observed, which disappears completely during the condition of "coma." BERGER, however, discovered that if narcotics are used which have only a specific stupefying influence on the thalamus, such as veronal, somniphene, dial, luminal, etc., in other words derivates of barbituric acid: $CO(NHCO)_2CH_22H_2O$, a considerable increase in electric activity of the cortex takes place. The more the function of the brain stem is blockaded, the greater the amplitudes of the encephalogram (KOOPMAN measured frequencies of up to 500 Hz; ROHRACKER, in Innsbrück, even of up to 2,000 Hz). This indicates that the cerebral cortex, one of the main sources of the α waves, functions more freely after the brain stem is blockaded. In order to create the phenomenon of "consciousness" the function of part of the cortex must be diminished considerably. We observe light as a result of differences in light energy, in other words because of the presence of shadows. Therefore, if all the parts of the cortex are strongly active as a result of total blockade of the thalamus, this condition of consciousness is not fulfilled. In other words the *condition of coma* can be created either if the cortex is completely stupefied (with narcotics) or if the activity of the cortex is increased considerably (by blocking the thalamus).
2. KOOPMAN and FRANKE discovered that as soon as the *hypnotic sleep* sets in the same activity of the cortex is observed as when the thalamus function was excluded with narcotics. The exclusion of the

thalamus function and the total liberation of the functions of the cortex might explain the reported cases of healing processes after hypnotic treatment.

3. Similar encephalograms were registered by KOOPMAN and FRANKE with persons, able to develop a condition of deep auto-hypnotic sleep, the *trance*, during which they are able to make drawings or paintings which normally they are unable to produce. The amplitudes increased enormously during the trance, but decreased at the end of this condition and were normal again after the person awoke. KOOPMAN and FRANKE therefore assumed that para-psychological capacities are connected with a certain structure of the brain and enables a person to exclude relatively easily the influence of the brain stem.

4. A combination of the blockading of the function of the thalamus (and increased cortex activity) and normal sensorial observation might explain the general mechanism of *clear-sightedness*.

5. KOOPMAN discovered also that the difference between a normal condition and hypnotic sleep shows up not only in the frequency and amplitude but also in the form of the curve. After a FOURIER analysis the normal curve is sinusoidal, whereas during hypnotic sleep the analysed curve is angular, i.e., the shape of a relaxation vibration.

This short review of the electro-magnetic fields of the brains during their function indicates that an almost inexhaustable terrain opened by the study of the electro-encephalograms. Further application of this method on divining phenomena might give an answer to many of the basic problems of life, the solutions of which might be a powerful weapon in the hands of the future scientists.

D. THE HEART
(see Bibl. No. 504a-510)

2. D. 1. Main structural element of the heart

The heart is another important source of electric fields in the animal body. It consists of four chambers (see fig. 16) capable of independent activity; the two upper chambers are the *atrium dextrum* (right side) and *atrium sinistrum* (left side), the lower ones *ventriculus dexter* and *v. sinister* respectively. For further anatomic details we refer to Bibl. No. 505. It has been calculated that during the lifetime of an averae man the heart beats 2,600 million times, pumping out at least 150,000 tons of blood from each ventricule.

The strength of the heart beat varies not only with the initial stretch induced by the degree of filling and with the chemical condition of the heart, but also by influences imposed on it by the rest of the body.

Nervous effects exerted through the nerves of the sympathetic nervous system and the nervous vagus (which derives from the spinal marrow) modified through reflex action are of great importance. These effects are probably produced through liberation within the cardiac structures of chemical effector substances *mediators*, which we discuss in the following pages. The heart is an organ probably richer in nerves than any other. They are activated by the symphaticus, whereas fibres of the nervus vagus can exert a checking effect.

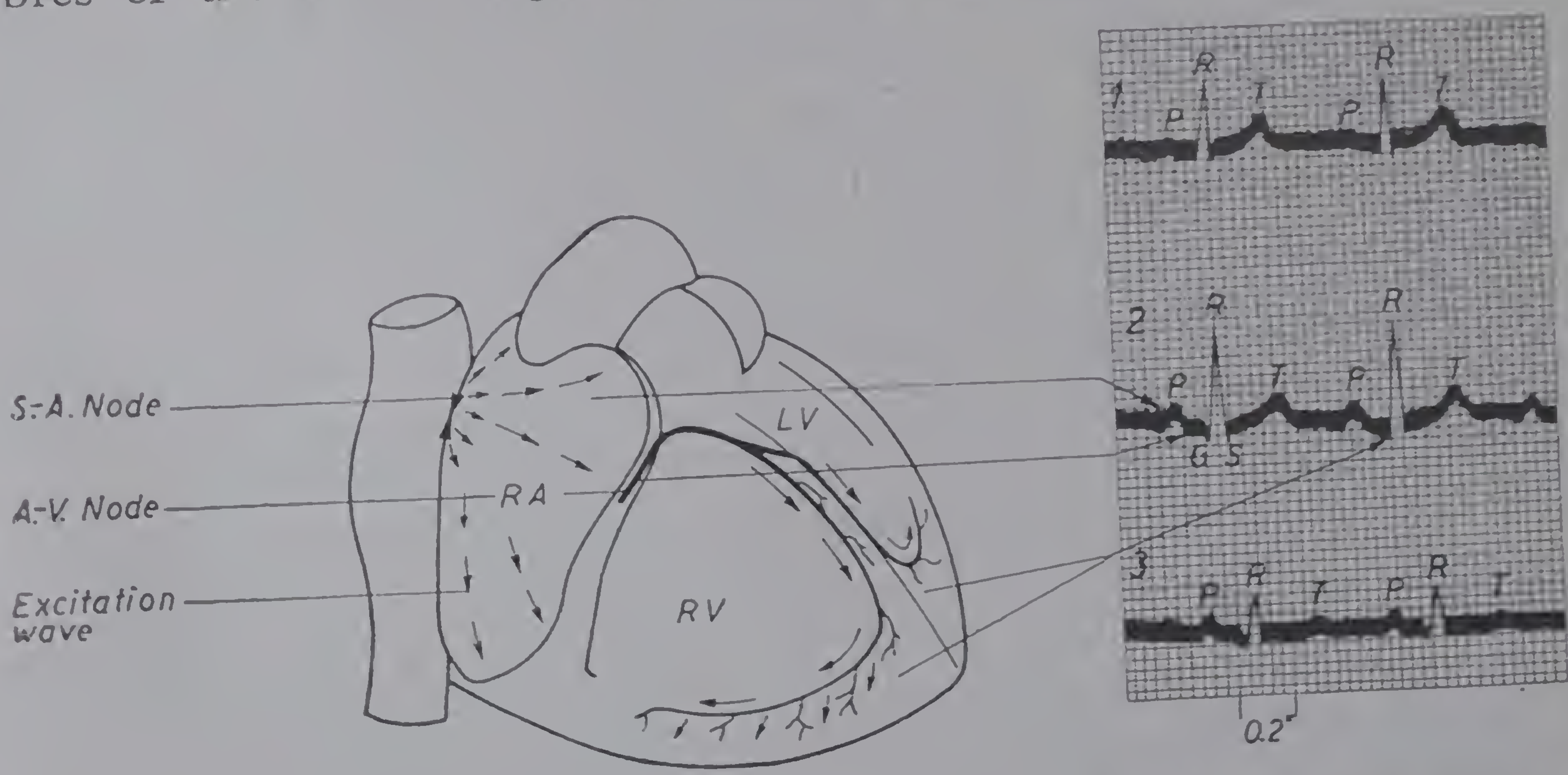


Fig. 16: (Bibl. No. 337) Electro-cardiogram, leads I, II and III, with diagram of the heart, showing schematically the origin of the electric waves.

The rhythmic contraction of the heart by the heart muscles has two effects:

1. the muscular contractions create alternating *action currents* in the heart tissues (see p. 160) (see also page 188, electric plethysmograph).
   Considerable fluctuations in electric potentials are created by these action currents (see fig. 16) which are transmitted by the blood stream to the body surface. They can be registered with a cathode ray oscillograph (see p. 145) or with a string galvanometer of EINTHOVEN (see p. 144), creating the repetition of the typical P-Q-R-S-T-curve (see fig. 16), the order of magnitude of the amplitudes being abt. 2 - 3 millivolt.

2. The heart acts also as a *pump*. It empties and fills the arteries and veins. The blood is composed of *electrolytes*. If electrolytes move through narrow tubes they create *"diaphragm currents"*, which vary with the viscosity and composition of the electrolyte, the speed of circulation of the fluid and the composition and structure of the vessels walls.
   The *viscosity* of human blood varies with males and females. The

apparent viscosity of normal males, in comparison with water, is 4.7 (4.3 - 5.3); for females 4.4 (3.9 - 4.9). The viscosity varies with the corpuscular content of the blood. Careful studies have shown that the fluid leaving narrow arteries has the same composition as the entering fluid, but that contained in the tube has fewer corpuscles. In very narrow tubes the corpuscles of the blood cannot pass without being distorted and the viscosity is determined by the resistance of the corpuscles themselves to distortion.

The *composition* of the human blood (see p. 77) also varies considerably, and shows up in *differences in the rate of red cell sedimentation* of males and females, man and different species of animals (depending on differences of *Rouleaux* formation, i.e., aggregation of red blood cells in plasma forming neatly piled cylindrical stacks of cells or rouleaux), varying also in case of diseases and pregnancy (enormously increasing the rate of sedimentation); *differences in blood groups* (due to differences in the erythrocytes and plasmas of different human races, see p. 77 and 398); *difference in blood pigments*: in vertebrates the *hemoglobin* contains 4% of *hemochromogen*, which is composed for 9% out of iron; in invertebrates, *hemocyanin* (a copper protein) has the function of hemoglobin.

In healthy adult males between 16 and 60 years of age the quantity of hemoglobin is abt. 15.6 grams per 100 ml of blood; in females it is abt. 10% less.

The *speed of circulation* of human blood is mainly determined by the frequency of the heart beats and the intensity of muscular contraction during each beat. It shows up in the blood pressure and the pulse rate, the average pulse rate of males being 65 - 75, of females 70 - 90 and of children 90 - 140. The diameter and structure of the walls (which determine the resistance) have great influence on the circulation speed.

Summarizing, we have seen that the total blood stream creates diaphragm currents (of the order of magnitude of a few millivolts), which vary in intensity for different organisms and for the different parts of the same body and which vary in males and females; the electro-magnetic fields (which are created round any electric current) create electric potentials on the surface of the body, the *skin potentials* (see p. 173), which are bound to show the same the variations in intensity.

In connection with the diaphragm and contraction currents it is interesting to remind the reader of the experiments of GAMGEE on the electric conductivity of hemoglobin (see Bibl. No. 506 b). GAMGEE discovered the following properties of oxyhemoglobin:

1. A solution of oxy-hemoglobin possesses low conductivity;
2. The conductivity increases rapidly with increasing temperature; a solution of 2.2% oxyhemoglobin has a conductivity of $2.23 \cdot 10^{-5}$ at 0°C, $7.47 \cdot 10^{-5}$ at 39° C;
3. If pure solutions of oxyhemoglobin are subjected to electrolysis

(see p. 61), a separation occurs of oxyhemoglobin in a colloidal but perfectly soluble form; this traverses animal membranes, which normally are impervious (during these experiments currents of 0.1 - 3.0 mA were used, with potentials of 12 - 24 V);

4. Continuous electric currents cause a rapid and entire transfer of colloidal hemoglobin from the anode to the cathode;
5. Being a typical colloid in its absolute indiffusibility through animal membranes, it differs from most colloids in the facility with which it crystallizes.

Experiment 3 and the electrolysis experiments reported on page 61 might particularly be of importance for the explanation of *stigmata phenomena* observed in certain para-normal women, such as reddish coloured tears at certain fixed periods (especially Fridays), appearance of 5 bleeding wounds on the hand, which disappear suddenly without leaving any scars, etc. (see p. 394).

2. D. 2. Causes of contraction

We have seen that the heart is analogous to a source of alternating current, which is situated within an extensive conducting medium. The potential of this current will vary at the same point from one moment to another with the constantly changing magnitude and orientation of the electric forces in the heart; generally different points will also have different potentials at the same instant. These rhythmical changes in electric potential, as a result of rhythmical concentrations of the heart do not seem be dependent on the central nervous system, as the excised heart continues to beat if kept in a balanced solution of salts. The exact origin of the heart beat is unknown, although two hypotheses give the most probable explanation for this amazing process.

The *neurogenic hypothesis* assumes that the contractibility is dependent on transmission of impulses to the muscular fibres of the heart; these are generated in the peripheral nervous tissue.

The *myogenic hypothesis* assumes that the contractions originate directly in the muscular tissues of the heart. The peripheral nervous structures and connections with the central nervous system might serve merely as a regulating mechanism. One of the arguments for this more generally accepted theory is the observation that the heart beats in the embryo chick before any nerve cells have grown into it.

Any excitable tissue, when activated, develops such an electric potential that the active area is negative to one that is inactive. The negativity spreads gradually along a muscle fibre, first one end becoming negative and finally both ends (if the fibres are relatively short).

The main site of the origin of the beat, the *pacemaker*, is probably

the *sinauricular node* (see fig. 10), although other parts of the auricle possess also the capacity of initiating rhythmical activity.

OSWALD invented a non-living mechanism, the *electric heart*, which was able to reproduce the rhythmic waves of excitation of the heart. His set-up was as follows: a globule of Hg about 2 cm in diameter is placed on a watch glass almost filled with 10 - 15% H_2SO_4; enough $K_2Cr_2O_7$ is added to render the acid light yellow. A clean serving needle, held in place by a cork, is placed diagonally so that the needle point just touches the margin of the Hg globule. At the moment of contact with the needle the globule flattens. This breaks the contact with the needle and the mercury becomes spherical (as a result of increased surface tension) and so again makes contact, which leads to another contraction. These rhythmic pulsations resemble the cardiac movements.

The cardiac muscle consists of *cross-striated fibres* (see p. 156) capable of more rapid contraction than a smooth muscle, but incapable of contracting with anything like the speed of skeletal muscle. Because of the branched arrangement of cardiac muscles a stimulus applied to the heart causes a contraction of all the fibres at once or none. The magnitude of the response does not vary with the strength of the stimulus; the contraction is immediately maximal, a phenomenon discussed on page 136 — the *all-or-none law*. However in skeletal muscles and nerves, composed of a large number of functionally independent units, graded stimuli applied to the tissue as a whole may produce graded responses.

The all-or-none law does not necessarily mean that the strength of the heart contraction is always the same. Both chemical environment and degree of initial stretch of the fibres exert great influence on the strength of the contraction. However *the strength of the stimulus does not influence the strength of the contraction.*

2. D. 3. Influence of chemical compounds

Several chemical substances influence cardiac activity:

1. *Potassium is essential* for normal cardiac function. An increase of 0.092% KCl in the solution surrounding the excised heart causes a slowing of the heart beat and finally a stoppage. Lowering of the potassium concentration causes a more rapid rhythm; if is is too low the heart concentration stops completely.

2. *Sodium salts* are also essential, apart from their function of maintaining a normal osmotic pressure in the fluid.

3. *Calcium* is essential, its absence causing smaller beats and finally stoppage of the heart.

   In other words a particular $\frac{Ca}{K}$ ratio is required for normal functioning of the heart.

4. The *hydrogen ion* concentration (pH) has a great effect on cardiac activity. According to ANDRUS and CARTER the frequency of the contraction of the rabbit's auricle is reduced if the pH of the solutions is lowered and vice versa. Alkaline solutions favour stimulation. The

theory is advanced that the stimulus depends on the potential difference between the inside and outside of the cells caused by differences in pH and that the other ions affect the magnitude of this potential difference by altering the permeability of the membrane. The heart rhythm is due to a rhythmic accumulation and discharge of a potential difference across a semi-permeable membrane.

5. The *vagus* exerts a slowing effect on the cardiac rhythm by affecting the pacemaker; it also causes a weakening of the contraction of the auricles by the action of chemical mediators liberated at the endings of the vagal post-ganglionic fibres, the mediator probably being *acetylcholine* (see p. 142).
6. The *sympathetic nervous system* is connected with the heart by accelerator nerves which create an increased activity. The acceleration shortens the *diastole* (i.e., the resting period between two successive systoles) more than the *systole* (i.e., contraction of the heart and particular ventricular contraction). The accelerating activity is mediated by *sympathin. Adrenalin* (secreted by the *adrenal glands*) and *thyroxin* (secreted by the thyroid gland) cause similar accelerating effects. These main chemical rules, which dominate the rhythmic processes of the heart and the electric potentials created in the blood stream and on the skin, indicate the great importance of external chemical compounds (particularly volatile ones) on living processes, if they are absorbed by the human body through the lungs, the membranes in the nose and mouth or through the skin (see also p. 138, laws of chemical excitation of nerves).

2. D. 4. Electro-cardiogram

The electric potentials of the action currents created by the contractions of the heart, are registered on photographic paper and are called *electrocardiogram* (E.C.G.). In chapter III on p. 312 we discuss the author's experiments on dowsing which were made with a string galvanometer of EINTHOVEN. Fig. 16 represents different types of recorded electrocardiograms.

The electrocardiogram can be measured in different ways. The standard leads of the electrodes of the string galvanometer used are:

Lead I: across the base of the heart; recording electrodes attached to left and right pulse of the arms.

Lead II: along the long axis of the heart; recording from the right arm and left leg.

Lead III: along the left margin of the heart; recording from the left arm and leg.

In fig. 16, the origin of the different electric waves as recorded in leads I, II and III is indicated.

The electrocardiogram shows a regular repetition of a typical curve, of which the characteristic points are indicated with the letters P-Q-R-S-T- (see fig. 16).

It has been found that the P wave is associated with the auricular systole; Q, R, S and T with ventricular systole. The waves Q and T represent the algebraic summation of the changes in the two ventricles. When the right ventricle is relatively large com-

pared with the left there is a tendency for the R wave to be small and the S wave to be very large (in lead I); in lead III the R wave could be very large and the S wave very small or absent.

If the left ventricle is very large the opposite condition is seen.

M. Plooy (Bibl. No. 510, p. 130) studied the variations of the T-top in electrocardiograms. The main results obtained by this author are as follows:

When a person was placed on a horizontal table and the angle of the table raised to 65°, he observed, particularly in the case of *orthostatic tachycardy*, differences in pulse frequencies (in one case it changed from 50 to 120) and in the electrocardiograms. The P-top often increased and invertion of the T-top occurred. The same took place (although less pronounced) when the person sat up; when he crossed his legs the whole difference practically disappeared.

These orthostatic changes show the following regularity:

1. They occur with many healthy but rather sensitive people;
2. The changes are greatest the more the pulse frequency changes after standing up.
3. The change occurs immediately after the change in position, but disappears also immediately after the person lies down again.
4. The changes differ during different hours of the day for the same person. They are smallest in the morning, in the afternoon a pronounced inversion of the T-tops often occurs.
5. Immediately after great exertion (e.g., the trial person raises his leg many times) the T-tops subside but during further exertion the tops rise again.

   Plooy explains the inversion of the T-curve as the result of the increase of the sympathicotonus.

   These changes do not influence the general curve or the average level of the peaks; this was observed during the experiments of the author (see p. 312).

For further details concerning the interpretation of electrocardiograms see Bibl. No. 505-510 and the biblographical references as mentioned in Bibl. No. 505.

E. The muscle
(see Bibl. No. 511-532)

2. E. 1. Main structural elements of the muscle

The structure of a muscle is rather complicated. Its function depends both on the muscular cells and nerves. The muscle is composed of a tender moist reddish substance, called *caro*, which is made up of elastic tissue, the actual *muscular tissue*, fat, connectivet issue, blood vessels, nerves, etc. The muscular tissue is composed from the periphery towards the centre of the following units:

1. *Vagina musculi:* Outer connective tissue which surrounds the different muscular fascicles.
2. *muscular fascicles:* Muscle bundles, each surrounded by a tissue called *perimysium internum*, which contains the many blood vessels and nerve endings mainly connected with the central nervous

system. Each fascicle is composed of different secondary muscle fibres, the *fibrae musculares*. Altogether a muscle is composed of thousands of individual fibres.

3. *Fibrae musculares*: Each secondary muscle fibre is surrounded by a sheath of connective tissue, the *sarcolemma*. It is beneath the sarcolemma that the complex and expanded collateral ending of the motor nerves terminates; it has been found that not every fibre is supplied by a special nerve fibre, but (in case of mammalian limb muscles) 100 - 160 muscle fibres are innervated by one motor neuron and its axon; at the region of the ending, the fibre is specialised by a mass of granular protoplasm in which are embedded many muscle cell nuclei (for neuromyal junction see p. 141); the fibres are soft, reddish coloured, of about the thickness of a hair, with a cylindrical form, four or five-sided with rounded edges; each fibre is composed of a great number of muscle cells.
4. *Muscle cells*: they are long spindle, shaped cells of which the protoplasmatic interior is surrounded by a very thin membrane. A number of very fine fibres occur in the protoplasm, the fibrillae, the actual active organs of muscular function. They run parallel to the longitudinal axis of the cell.
   There are two kinds of muscle fibres; *cross-striated fibres* and *smooth fibres*, which form the *cross-striated* and *smooth muscles*. The nerve supply of smooth muscle is rather peculiar:
   a. a peripheral neuron is interposed between the central nervous system and the effector;
   b. many smooth muscles receive fibres from the symphathetic nervous system.
5. *Fibrillae musculares*: very fine parallel fibres, which are considered as the smallest particles of the body; according to GEGENBAUER they are 7 — 15 μ or less.

The muscle is characterized by its *capacity to contract*. The muscular cell shortens along the longest axis, causing a thickening of the muscle cells and the muscular fascicles. Even at rest the muscle has a certain tension, known as *tonus*. RAMSAY and STRUT (Bibl. No. 525) studied the isometric *length-tension diagram* of single striated muscle fibres of the frog. They showed that maximum tension is developed at rest-length, that the muscle is still functional and can develop a small tension when it is extended to twice its rest-length and that it can shorten until it is only 19% of its original resting length. The extent to which a single muscle fibre can shorten does not appear to be governed by the contractile mechanism but by the sarcolemma. If the sarcolemma is thick and strong, as in some toad fibres, maximal shortening is small, simply because there is not enough force to bulge and stretch it.

However, if the sarcolemma is thin, the shortening can be extensive.

Two kinds of muscles can be distinguished: the *musculi voluntari* and the *musculi involuntari*. The first group is mainly controlled by the

central nervous system, the latter by the sympathetic nervous system. The musculi voluntari are generally composed of cross-striated fibres, the involuntari of smooth fibres, although many exceptions occur, e.g., the heart muscle being involuntari, is composed of cross-striated fibres (see p. 153), the same being true for the muscles in the throat and œsophagus.

Three parts are distinguished on each muscle: the head or *caput* (which starts at a fixed point of the body), the *venter* (the thickest meaty centre part) and the *cauda* (connected with a movable joint). A textbook on muscular anatomy should be consulted for further anatomical details.

2. E. 2. Sources of energy

The contraction of muscles depends upon the occurrence of certain chemical processes within the muscle fibres, which yield the energy required for muscular work. This activity leads to the condition of *fatigue*. Other reverse chemical processes must take place to remove the waste products before the original power is restored to the muscles. Both chemical processes yield heat.

The chemical energy required for the muscular action is obtained by two processes: the carbohydrate metabolism and fat metabolism.

Carbohydrate metabolism:

The methods by which a skeletal (cross-striated) muscle uses oxygen and gives off carbon dioxide are ruled by chemical processes in which two main components, the *carbohydrates* and *oxidative enzyme systems* play an important role.

An *enzyme* is a biological *catalyst* (i.e., substances often secreted by certain animals and plants enabling very complex chemical reactions to proceed rapidly at rather low temperatures) accelerating a reaction to its equilibrium point. Its value lies in the fact that while growing and multiplying, it secretes within each cell small amounts of very active substances which are dissolved in the cell contents.

Enzymes show resemblances both to the living and non-living substances but most likely they are non-living complex organic compounds related to the proteins. Before an organic molecule is oxidized it often needs a certain enzyme, called oxidase. For the activation of hydrogen atoms in inorganic molecules enzymes called *dehydrogenases* are often required.

The important oxidase in muscular processes is, according to McMunn and Keilin, *cytochrome*. It may be rapidly oxidized and reduced and may aid in the acceleration of the oxygen uptake. The metabolism of *carbohydrates* (*sugars*, the *starches* and the *celluloses*) in muscles begins with *glycogen* $(C_6H_{10}O_5)_n$ and ends with the products of the combustion of this substance. The exact chemical nature of glycogen is unknown. It resembles ordinary starch and occurs in the liver, muscle and white corpuscles of the blood.

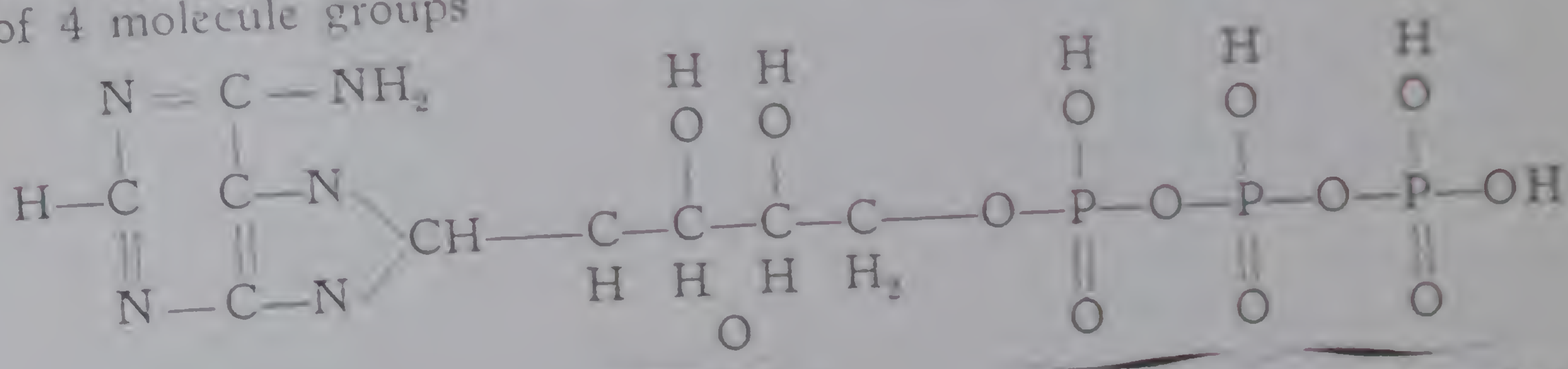
During stimulation of a muscle under anaerobic conditions, glycogen disappears and is broken down into *lactate* $(CH_3CHOHCOO)$ with the aid of enzymes. During recovery of the muscle in oxygen the lactate is removed (abt. 3 - 4 molecules of lactate are reconverted to glycogen for every one that is oxidized).

The formation of lactate seems to take place partly during contraction but much is produced after the period of contraction and relaxation is over. In other words the formation of this substance is not the main reaction from which energy for contraction is immediately derived. The production of lactate, however, is associated with the development of tension in the muscle as it causes the swelling up and shortening of the cells.

Next to glycogen two other unstable organic compounds, containing phosphate, play an important role in muscular activity of man, *phosphocreatine*

$$HN = C \begin{cases} NH\text{—}PO(OH)_2 \\ N(CH_3)\text{—}CH_2\text{—}COOH; \end{cases}$$

adenylpyrophosphate, with an extremely complicated formula composed of 4 molecule groups



adenine *ribose* *phosphate pyrophosphate*

adenylpyrophosphoric acid

Creatine phosphate also occurs in smooth muscles of vertebrate animals and in the muscles of invertebrates *argininephosphate*. According to ENGELHARDT and LJUBIMOWA (Bibl. No. 515 a) the enzyme that catalyses the breakdown of these phosphate compounds is *myosin*. It is believed to be the most important energy-producing reaction in a muscle following stimulation. The energy released during the reaction is probably used to restore potential energy lost from the crystalline mysosin structure in contraction.

Continuous muscular contraction for long periods breaks down the phosphocreatine which is transformed into *hexosephosphate* (a phosphatic kind of sugar-carbohydrate); this process is reversible during the recovery period. Adenylpyrophosphate disintegrates in the above-mentioned components after continuous muscular contraction.

The actual chemical process in a muscle is a complex combination of the three reactions described above.

Fat metabolism:

Next to carbohydrates *fats* are disintegrated, a process known as *fat metabolism*. It takes place particularly if the carbohydrate supply in the muscles is diminished. The fats are converted to *acetone bodies*. These processes create the energy required for muscular contraction.

The oxygen consumption of *smooth muscles* is less than that of *cross-striated muscles.*

In *heart muscles* the recovery period is only 0.75 sec, while skeletal muscles may need hours for recovery. The oxygen supply into the tissues therefore requires a special mechanism in the heart muscles; the capillary length per $m.m^3$ of the cardiac muscle is 11,000 mm in contrast to 6,000 mm in active skeletal muscle.

Several factors cause variations in the process of muscular metabolism: species and age of the animal, previous diet, duration of fasting, condition of the endocrine organs (i.e., glands with internal secretion), season of the year, cyclic changes and the state of the animal or person (anesthesia, blood pressure, stunning etc.)

2. E. 3. Causes of muscular contraction

The physical processes that determine the actual mechanism of the muscle machine are unknown but two hypotheses have been put forward (see Bibl. No. 526) which give a reasonable explanation of these processes.

1. According to the theory of ENGELHARDT and LJUBIMOWA (Bibl. No. 515 a) *the basis of contraction of a muscle is considered to be the more or less random disorientation of previously oriented myosin components*, either molecules or micellac. This process is compared with the long-range elastic behaviour of a rubber band.

It is assumed that the individual hydrocarbon molecules of rubber are flexible and can exist in a number of configurations having different overall lengths; the most probable configuration depends on the temperature, being more condensed and shorter at a higher than at a lower temperature. If a rubber band is stretched, the molecules will be pulled out of their most probable configuration for that temperature and will exert a force as a consequence of being in an improbable state. The work done appears as heat. On removal of the stress the molecules absorb heat from their surroundings and return to their most probable state, thus shortening the band. *No change in internal energy takes place, only a decrease and increase in entropy.* By analogy the myosin molecules of muscle are considered held in an improbable state by a stabilizer which, removed by the stimulus, allows them to shorten to a more probable state. Energy for contraction derives from the increase in entropy of the molecules. It may be possible to devise a system in which the myosin molecules at rest are in their most probable state, so that contraction creates a decrease in the entropy.

2. *The theory of* ASTBURY (Bibl. No. 512) *assumes that the myosin exists in the form of long, more or less continuous polypeptid chains capable of existing in several definite states of folding.* Contraction, on stimulation of a nerve, is explained in this case as a folding phenomenon. *Length changes involve changes in internal energy of the molecules.* ASTBURY assumes that myosin can exist in at least 3 states of folding:

α *myosin:* a half-folded state characteristic of resting muscle;
β *myosin:* a fully extended state characteristic of stretched muscle;
γ *myosin:* a super-contracted state characteristic of shortened muscle;
β Myosin would have a length twice that of α myosin and γ myosin would be $\frac{2}{3}$ of α myosin.

In both theories *the energy for contraction is derived from energy previously stored in the structure*, the implication being that energy for restoration or relaxation is derived from accompanying chemical reactions.

Up to 1939 most physiologists believed in another energetic cycle, because FENN (Bibl. No. 516) had discovered that a muscle liberates more energy in shortening when work is done than when no work is done. In other words it was thought that *energy is mobilized for contraction from chemical stores* and relaxation is essentially a passive phenomenon. This contradiction is less serious, however, than it might look. Each folding mechanism created by two opposing forces requires different quantities of energy depending upon whether both forces are equal (e.g., one force pressing against a non-movable wall, creating a reaction force equal to the action) or not. In the latter case, e.g., in the example of the wall, the point of application might recede; this requires a greater force to fold a layer (between the wall and the primary folding force) to the same extent as with a non-movable wall.

Summarizing, it is assumed that the effect of a stimulus is to release potential energy previously stored in the myosin structure. This can then be used for doing external work or be degraded to heat in shortening by satisfying chemical bonds within its structure. If no shortening occurs, no potential energy is lost by the myosin. In relaxation, chemical energy restores any potential energy lost by the myosin structure. The studies of RAMSAY and STREET on the *length-tension diagram* (see p. 156) are very instructive in this respect (see Bibl. No 526).

It is well known, after the discovery of "animal electricity" by GALVANI in 1786, that if we connect a recording instrument by means of two non-polarizable electrodes with two parts of a strip of parallel-fibred muscle that has been functionally denervated, a wave of electric disturbance is set up whenever a wave of contraction passes over the muscle from one end to the other; the part which first contracts becomes electrically negative to the rest of the muscle, but as the waves proceed the negativity decreases and when the contraction wave reaches the farther end of the muscle, this in turn becomes negative. The instrument registers a *diphasic action current*. No difference of potential is recorded when electrodes are placed on a resting, uninjured muscle. However, if the muscle is injured, this part becomes negative and a positive current flows toward the injured area, the *current of injury* (see also p. 19).

The chemical processes in the muscle seem to be responsible for these action currents in contracting muscles. Part of the released energy is transformed into heat, partly into electric energy. According to the *alternating theory of* HERMANN-HERING this action current is caused by changes in concentrations of the hydrogen ions in the muscle-cells, as a result of the above-mentioned chemical processes.

The muscle has been compared with a non-commercial motor, the LIPPMANN'S

electrocapillary motor. In this mechanism two bundles of glass capillaries float on Hg covered with dilute H_2SO_4. Because of the surface tension Hg stands deeper in a capillary, thus lifting the capillaries. Through passage of an electric current by cathodic polarization, the surface tension of Hg is decreased. Consequently, the bundle drops like the plunger of a vertical steam engine. By connecting the capillary bundles by rods and a cam to a flywheel, which through another cam, operates a pole turner, a continuous automatic movement is obtained. This, in an alternating current, tends to effect a downstroke (equal to muscular contraction) of the other bundle at definite moments (see Bibl. No. 526, p. 82).

2. E. 4. Heat production of muscles (see also p. 119)

We have seen that the energy released during chemical processes in the muscle is partly transformed into heat energy. Two processes must be distinguished: heat development during and after the contractional phase.

The first process creates *initial heat*, composed of two components: the *contraction heat* (which rises and falls during the development of tension) and the *relaxation heat* (which begins as relaxation sets in). After the contraction is over the *delayed* or *recovering heat* is developed. Experiments have shown that the chemical changes which give rise to the initial heat are wholly non-oxidative. However, the greater part of the delayed heat is dependent of the presence of oxygen (*oxygen-recovery heat*); only a very small part is non-oxidative heat (*delayed anaerobic heat*). If we give the initial heat the value of 1.0 the relative values for the different heat components are as follows: contraction heat 0.65, relaxation heat 0.35, delayed heat 1.24, delayed anaerobic heat 0.08, oxygen recovery heat 1.16. The most important changes in the muscle take place as *aerobic processes*, a process known as *respiratory metabolism*.

2. E. 5. Electromyogram

An automatic registration of the potential fluctuations during muscular activity is called *electromyogram* (E.M.G.). They can only be measured with instruments sufficiently sensitive and not too slow in reaction speed. Originally the *capillary electrometer of* Lippmann and the *string galvanometer of* Einthoven (Bibl. No. 506a) was used. However, in order to measure the potential fluctuations of separate units in the striated muscle it must be possible to register 10-200 microvolt with frequencies up to 100,000 Hertz. This is only possible by using cathode ray-oscillographs with special amplifiers (see Bibl. No. 521a and 528), which increase the sensitivity 10^5-10^6 times. Wedensky (Bibl. No. 532) in 1883 was the first to demonstrate, with two needle electrodes and a telephone as indicator, that contraction of the biceps creates a noise with a rhytm of 30-40/sec. Piper (Bibl. No. 522a) confirmed this observation and registered this E.M.G. with a string galvanometer. He discovered in the irregular curve of the action currents during strong

contractions of striated muscles, waves with large amplitudes and frequencies of abt. 50/sec. This PIPER-*rhythm* (see fig. 18) is, according to PIPER, independent of the intensity of the contraction (at least above a certain minimum value).

WACHHOLDER (Bibl. No. 531) repeated these experiments, but observed a relationship between frequency of the large waves and contractional intensity. Two rhythms in the human E.M.G. were found: A-*waves* (large, rather regularly occurring waves, see fig. 18) and B-*waves* (smaller and more irregular); on the A- and B- waves small secondary peaks were sometimes observed. The frequency of the A-waves increases from 5-65/sec with increasing muscular contraction; the frequency of the B-waves varies between 180-250/sec but are independent of the contractional intensity.

SIEMELINK (Bibl. No. 528) repeated the experiments of WACHHOLDER and explained the contradiction between PIPER's and WACHHOLDER's observations as follows: it is not the frequency of the A-waves which is dependent on the contraction intensity, but the frequency of the motor unit discharges which shows this relation.

SIEMELINK observed a considerable decrease of the frequency of the A-waves with increasing refrigeration of the muscle; the wavelets disappeared and the whole myogram was more smoothly developed; the shape of the discharge curves of the separate motor units also changed.

ADRIAN (Bibl. No. 511) and his collaborators, using modern amplifiers and very selective electrodes, could prove that the E.M.G. taken from the whole striated muscle is composed of rhythmic discharges of a great number of smaller units, the *motor units*; one motor unit comprises a motor neuron with one neurite and terminal collaterals and a number of muscular fibres (abt. 100-160) which are stimulated practically at the same moment by these collaterals. In 1928 ADRIAN and BRONK registered the first electro-neurogram of one motor unit. It was found that during a respiratory movement in one nerve fibre of a rabbit a regular succession of electric discharges took place, of equal intensity amounting to 20-30 discharges/sec, with strong inspiration, even 50-80/sec.

The discharge in the nerve part of one motor unit amounts to 50 μ volt, in the muscular part 200 μ volt. The tetanus tensions of a single average motor unit of a cat measured by ECCLES and SHERRINGTON, amount to 30.1 grams for the gastrocnemius, 5.5 grams for the semitendinosus; the twitch tensions are approximately one fourth of these values.

SIEMELINK (Bibl. No. 528) could demontrate that the presence of a number of regularly occurring discharge-peaks in the myogram, all with the same form, are due to one, not several motor units. The discharge peaks indicate that the motor unit discharges are not monophasic, but poly-phasic (i.e., two or more small peaks close together), which is probably the result of the muscle fibres of one motor unit not discharging simultaneously (see fig. 17).

Experiments by ASHER (Bibl. No. 511a), VOSER (Bibl. No. 530) a.o., indicate that the impulses are not created only by spinal motor-nerves, but also the sympathicus seems to cause certain impulses in the motor units. These observations however, were not confirmed by SIEMELINK (Bibl. No. 528).

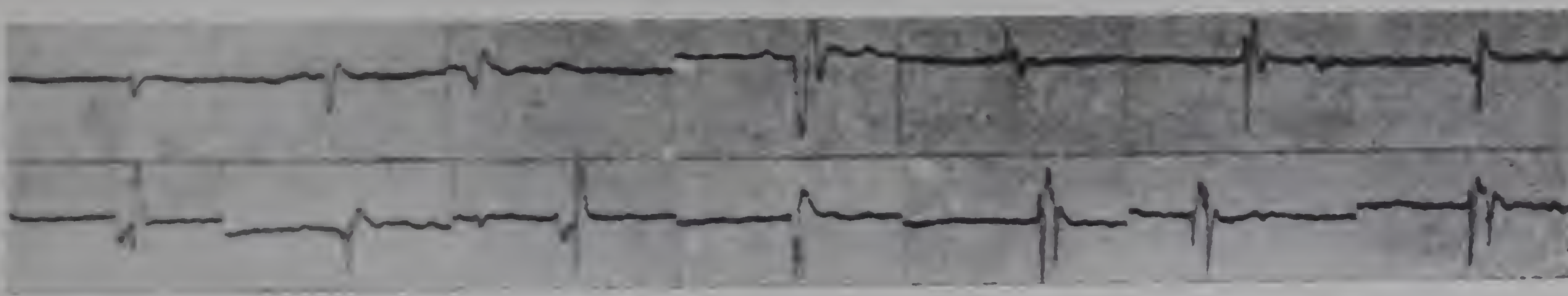


Fig. 17: (Bibl. No. 528, fig. 29) Electromyogram showing that discharge peaks of motor units are generally not mono-phasic but poly-phasic.

ADRIAN pointed out that with increasing rate of contraction not only the number of active motor-units increases but also the frequency of the electric discharges of each separate unit. With high rate of contraction in the different motor units, there is an increasing tendency to create *synchronous discharges*; this is demonstrated by the observation that during strong respiratory movements the frequency of discharge of one single nerve-fibre is equal to the maximal frequency of the neurogram of the nerve as a whole. According to ADRIAN this process can explain the great amplitudes of A-waves, but this was not confirmed by the experiments of SIEMELINK (see later). It is evident that a slight disturbance in the regular discharge of the motor units can change immediately the rate of muscular contraction.

ADRIAN noticed that a great difference often exists between the neurogram of sensory and motor nerves.

The discharge of nerve fibres of a sensory nerve takes place at random; the neurogram shows an irregular curve of the action currents, with a very high total frequency of small peaks.

The discharge of motor nerves during great activity shows a tendency to form regular groups of larger peaks (A-waves).

SIEMELINK (Bibl. No. 528) does not believe that the A-waves are the result of synchronization of the discharges of the motor neurons. In order to prove this he pointed out that:

1. with constant loads no definite relation exists between the absolute values of the frequency of the A-waves and those of the motor unit discharges;
2. (as mentioned previously) the A frequency does not depend on the muscular tension, whereas the motor-unit frequency does (see fig. 18);
3. the frequency of A-waves varies between 30-50/sec, whereas the motor unit discharges possess a maximal frequency of less than 30/sec.

SIEMELINK explains the PIPER rhythm as an *interference phenomenon.* By using 8 asynchronous electric generators, which give electric discharges with frequencies and form similar to those of the motor units, it was possible to create a total picture resembling the PIPER rhythm, if the generators were connected in series.

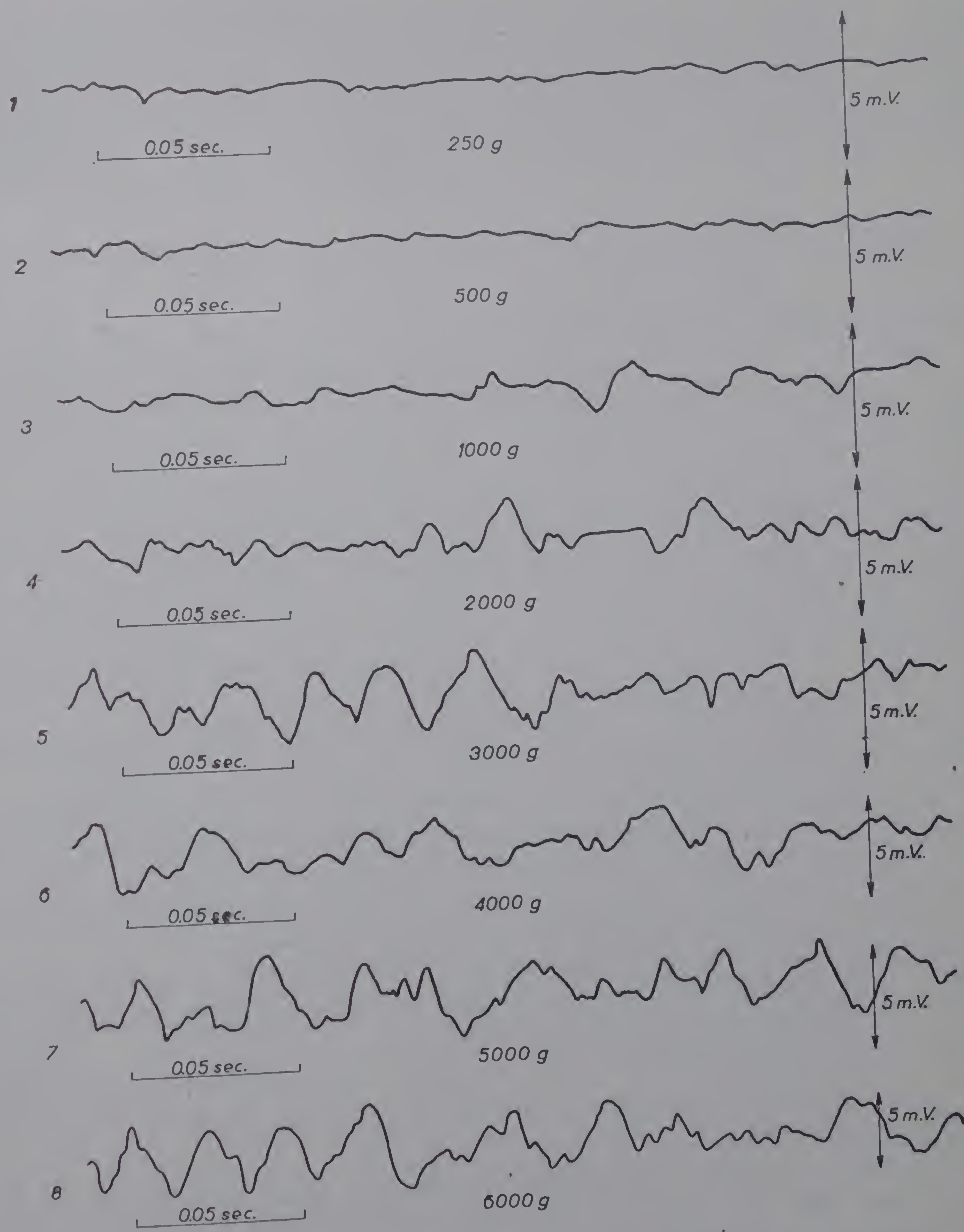


Fig. 18: (Bibl. No. 528, fig. 15) Electromyogram showing A-waves with varying muscular tension; above a certain minimum value (curve 1-4) only the amplitude, (not the frequency) of A waves is dependent on the external load.

2. E. 6. Laws of electric excitation of muscles

A distinction must be made between the cross-striated muscles, such as the skeletal muscles, and the smooth muscles.

Exitation of cross-striated (skeletal) muscles

1. *The unit of muscular activity, the simple twitch, originates either by direct electric stimulation of the muscle (induction shock), or indirectly by a single volley of electric discharges in the motor nerves*, set up by the central nervous system as a result of internal or external exciting forces (*indirect stimulation*).

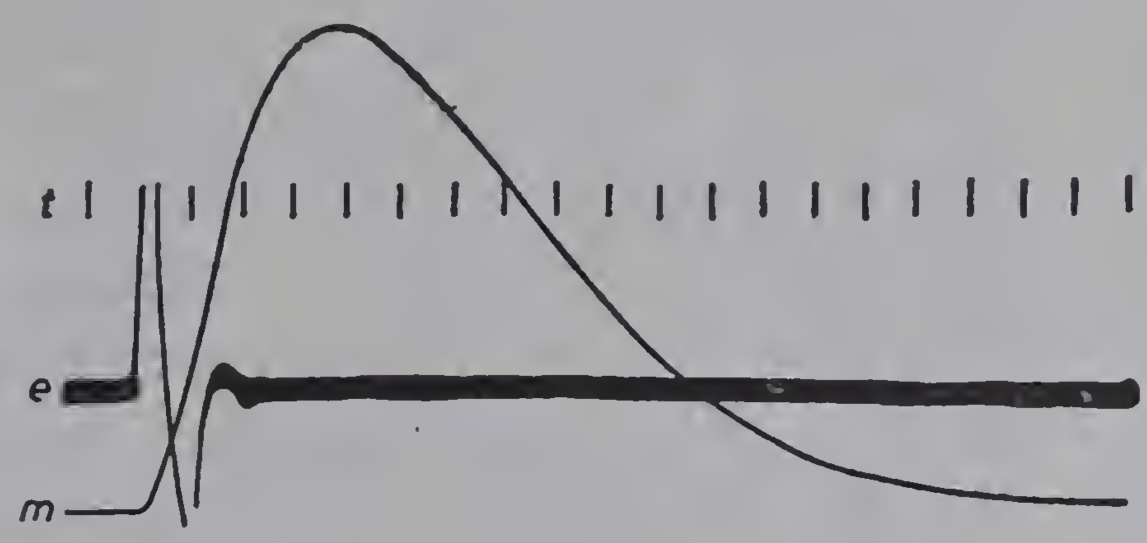


Fig. 19: (Bibl. No. 337, fig. 9) Isometric twitch of extensor digitorum longus muscle of cat; t = time record in hundredths of a second (After Creed, Denny-Brown, Eccles, Liddell, and Sherrington).

2. *The twitch has three intervals:*
   a. the *latent period*, i.e., the time that elapses between the application of the stimulus and the first appearance of shortening or the exertion of tension by the muscle;
   b. the *period of contraction*;
   c. the *period of relaxation.*

   Brown and Sichel, in a study of the contraction of isolated single muscle fibres, found latencies of 1.5-2.5 $\cdot$ 10^{-3} sec, in case of direct stimulation.
   Roos found latencies for frog muscle (gastrocnemius) of 0.4 $\cdot$ 10^{-3} sec. These *true latencies* are, of course, shorter than the *apparent latencies*, i.e., stimulation through the nerve muscle.
   The *period of contraction* of an isometric twitch begins abruptly abt. 1.0 $\cdot$ 10^{-3} sec after the onset of the electric response. A myogram curve shows a very short phase of upward concavity, followed by an upward convexity to the summit of the potential curve (see fig. 19).
   The period of relaxation is formed, first, by a continuation downward of this same upward convexity and then by a gradually developing concavity which continues till the resting tension is reached. It is slightly longer than the period of contraction.
   The interval between the beginning of the muscular action current (which originates after the nerve excitation has started) and the attainment of maximum tension (the summit of the isometric myogram) marks the duration of the contraction process and is

called *contraction time*. Muscles are divided into "*slow*" and "*rapid*" *muscles* according to this time.
The solens of cat has a contraction time of $100 \cdot 10^{-3}$ seconds, the internal rectus of the eye $7.5 — 10 \cdot 10^{-3}$ sec.
The contraction time is different, depending on the muscle being allowed to shorten (*isotonic contraction time*) or keep its original length during the development of tension (*isometric contraction time*), the former is shorter.

3. *The law of maximal response of skeletal muscle:*

   The cardiac muscle is regulated by the all-or-none law (see p. 153), i.e., the weakest stimulus, if it produces any response at all, produces a maximal strength of contraction at once. The skeletal muscle, however, is composed of different fibres, each of which may contract independently of the others. The fibres are also insulated from one another in such a manner that the disturbance set up by the stimulus in one does not spread. *Each simple muscle fibre is regulated by the all-or-none law*, but because of different threshold values of the motor nerves and the graded stimuli not all the muscle fibres of the muscle will give a maximal response at once. The fibres in the cardiac muscles are connected in a *syncytium*, creating an immediate response.

4. *The magnitude of maximal contraction is not always the same.* The ability of the fibre to develop tension varies from time to time and depends on a variety of factors.

   a. *The energy set free in a contractile process is greater the longer the muscle*, at the time when it begins to contract; e.g., a muscle,

Fig. 20: (Bibl. No. 337, fig. 12 and 13)
A) The effect of successive stimuli on the tension developed by skeletal muscle, showing the staircase phenomenon or treppe (after FULTON).

   when stretched at the moment when it begins to contract, can develop a greater final tension than an unstretched muscle.
   The heat development (see p. 161) also increases in a similar manner with the initial length of the muscle.

   b. *A muscle develops more energy in a twitch if it contracts against a load, than if it is given no work to do* (FENN effect); in other words the magnitude of the all-or-none output of energy depends

not only on the condition of the muscle before it contracts (sub a) but on the conditions it meets while contracting. This mechanism is dicussed more in detail on p. 160.

c. *If a muscle is excited to maximal contraction several times in rapid succession, each twitch is somewhat higher than its predecessor,* a phenomenon known as *treppe* (see fig. 20a). It is explained by the fact that chemical changes arising from one contraction enables the muscle better to contract the next time.

d. *If the successive stimuli are continued for some time* (20-60 min according to ROSENBLUETH), *the height of the contraction soon reaches a maximum and then begins to fall off* as the muscle becomes *fatigued.* Fatigue results partly from the fact that after prolonged activity each fibre in the muscle develops less tension when it contracts, and partly from decreased excitability of the nerves (see p. 137).

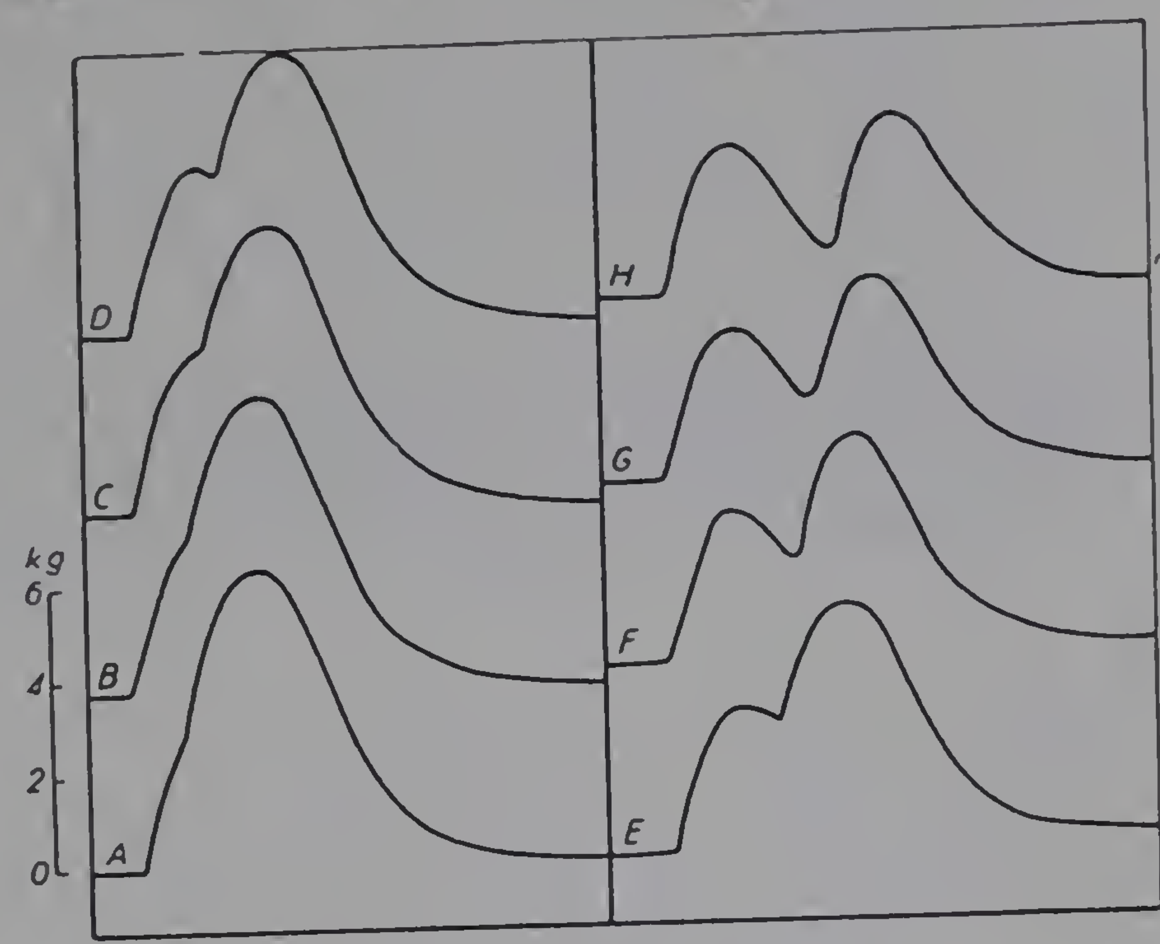


Fig. 20: B) Summation of contraction in skeletal muscle. Isometric response of median head of gastrocnemius of cat to two maximal stimuli (after COOPER AND ECCLES).

e. *Law of summation of contraction;*
(α) *If a muscle or its nerve is stimulated twice in such rapid succession that the second stimulus falls during the response to the first, the degree of shortening or the amount of tension developed is greater than in the single twitch* (see fig. 20b and p. 98, law of TALBOT). Since it occurs when each of the two stimuli is maximal, this phenomenon cannot be caused by the excitation of a greater number of fibres; each fibre contracts with greater force, a process related to the treppe phenomenon. This increased tension might be 3 times that of a single twitch.
(β) *If a continuous series of rapidly repeated stimuli are sent into the muscle the result is a prolonged contraction* in which the component responses are so completely fused that they cannot be distinguished; such a response is called *tetanic contraction* or *tetanus.* The tension developed might be 4 times that of a simple twitch.
The shorter the contraction time the greater is generally the required tetanic frequency of stimulation. In the cat it is 30 per second for solens and 350 per second for the internal rectus of the eye. If the rate of stimulation is sufficient for summation but not rapid enough to cause complete fusion, the myogram shows

a partially maintained undulatory plateau called *incomplete tetanus*. If all myographic evidence of the repetitive nature of the response is lost, it is called *complete tetanus* (see fig. 21).

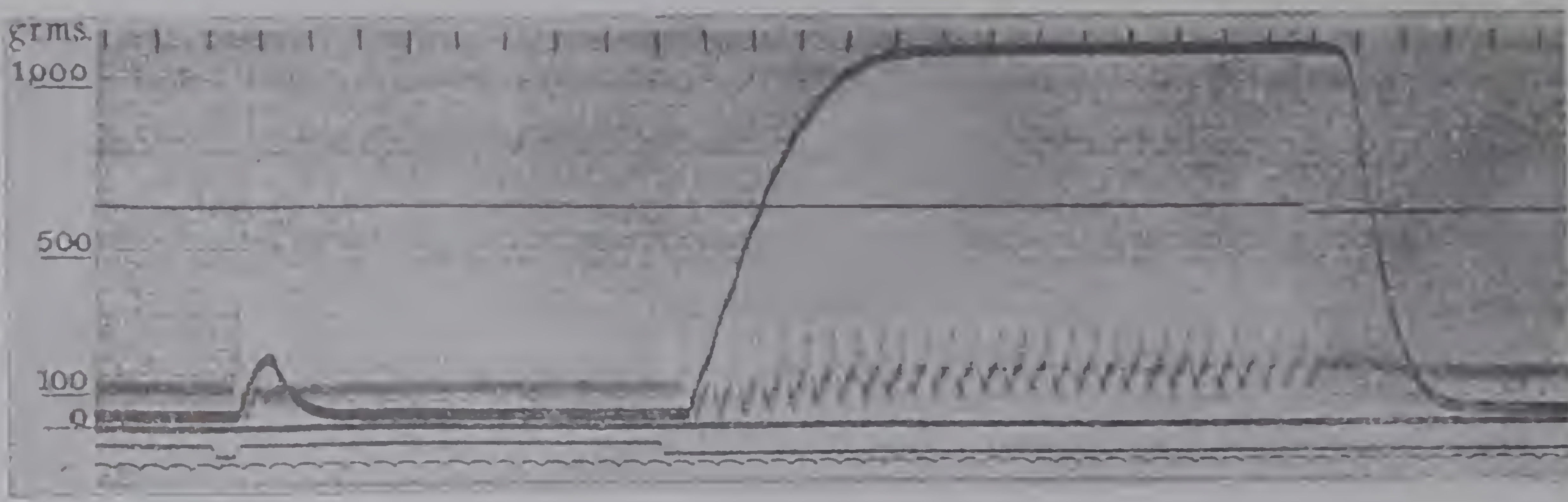


Fig. 21: (Bibl. No. 337, fig. 14) A single isometric twitch followed by an isometric "tetanus" (after FULTON).

(γ) *Summation does not occur if the intervals between two stimuli sent into a muscle are sufficiently brief;* in other words the muscle cannot be excited for a short interval following one excitation; this interval is called the *absolute refractory period.*

(δ) *After the termination of the absolute refractory period the excitability of the muscles gradually recovers;* a stronger stimulus is required to produce summation in the response than is needed to initiate contraction in a resting muscle. This period of depressed excitibility is called *the relative refractory period.*

The absolute refractory period in cardiac muscle terminates at about the time the muscle commences to relax. The relative refractory period extends throughout the period of relaxation. As a result only in exceptional conditions can the heart muscle contract again before it has time to relax. This property of the heart muscle assures the rhythmic heart beat.

5. *Increasing temperature and acidity tend to cause muscular contraction.*

This extensive summary of the laws of electric excitation of skeletal muscles is necessary as most phenomena of waterdivining can only be explained if the mechanism of muscular contraction is thoroughly understood.

Excitation of smooth muscles

The smooth muscles of the mammalia differ markedly in size and histological appearance from skeletal muscles (see Bibl. No. 514a-c); this results from their different origin (smooth muscles arise from the mesenchyme, the skeletal muscles from the mesodermal somites).

Smooth muscles are very important to the mammalian body. Without them ingested food could not pass through the alimentary canal, they maintain and regulate proper circulation of the blood, they regulate the amount

of light admitted to the retina (see p. 114), the size of the bronchioles, the volume of the spleen, etc. The most important properties of the smooth muscles are as follows:

1. *Many smooth muscles* (both excised and in situ) *exhibit rhythmic contraction* which, unlike skeletal muscles, are not entirely dependent upon connections with the central nervous system. These contractions are sluggish and never develop great tension; the rhythm is often only myogenic in origin (see p. 152), in other instances both myogenic and neurogenic.

2. *They possess the tendency of a sustained persistent contraction known as tonus; they can alter their tonic condition by appearing at different lengths under equal degrees of tension;* e.g., the pressure in the urinary bladder remains much the same whether it contains 50 or 150 ml urine.

3. *Smooth muscles respond to a greater variety of stimuli than skeletal muscles;* i.e., mechanical, electric, thermal and chemical stimuli can excite them. As a result:
   a. they are often excited to contract by extension;
   b. mechanical or electric stimulus evokes relaxation when the muscular tonus is great;
   c. increased acidity causes relaxation and quiescence, while increased alkalinity induces a higher degree of tone and more marked rhythm;
   d. rise in temperature as a rule produces relaxation, cooling causes contraction.
      Excessive acidity and rising temperature (up to 50°C) cause a fully relaxed state of the smooth muscles; in similar circumstances skeletal muscles tend to contract;
   e. drugs and hormones have a specific action on smooth muscle.

4. *Smooth muscles behave plastically after application of a load.*
   BOZLER (Bibl. No. 514b) studied the smooth muscles of Pecten and found the following features:
   a. when a load is applied to the resting muscle it suddenly lengthens and then continues to lengthen slowly. In this respect it behaves quite differently from an elastic band or skeletal muscle;
   b. when a muscle is suddenly stretched, it develops tension like an elastic band. If the new length, however, is maintained, the tension, unlike that of a stretched elastic band or skeletal muscle, drops and disappears within a short time along an exponential curve, a phenomenon called *release of tension* in order to distinguish it from the relaxation of an active contraction.

These few examples demonstrate that smooth-muscle action is ruled by several laws, completely different from those of the skeletal muscles. It has been assumed that smooth muscles are not organized

on the basis of motor-units and that they do not obey the all-or-none law. This probably is not completely true for all smooth muscles. BOSLER demonstrated that electric excitation does not need to take place through motor nerves, but can occur directly through conduction from one muscle cell to another. These smooth muscles show a definite strength-duration curve (see p. 168), a definite absolute refractory period and obey the all-or-none law. It is very likely that liberation of *chemical mediators* (see p. 142) play an important role in the innervation of the fibres, which may act graded by differences in diffusion speed of the membranes surrounding the fibres, etc. The fundamental properties of smooth muscles are still insufficiently known. A better understanding of their mechanism could help to solve many of the divining phenomena discussed in chapter III.

2. E. 7. Transmission of excitation at neuro-myal junction

We discussed on p. 141 the mechanism of excitation of a striated muscle at the neuro-myal junction.

An artificial arrangement which approaches a nerve muscle combination has been described by BEUTNER (Bibl. No. 526, p. 83). It is a modification of the LIPPMANN's electro-capillary motor, described on p 161. A bundle of capillaries, kept floating on mercury (covered with sulphuric acid), is connected electrically to the end of passive iron wire, kept in HNO_3 (see artificial nerve, p. 139), by extending the passive iron into Hg through the glass container and connecting the H_2SO_4 with the HNO_3 by an agar bridge. If a single wave of polarization travels along the iron wire and hits on the connection to the capillary bundle, the temporary change of potential difference at the end of the iron wire will lead to flow of current through the agar bridge connecting the wire and Hg. Consequently the surface tension of Hg decreases and the bundle of capillaries drops. As in a muscle, the movement is temporary, and is equivalent to a single muscle twitch. After the wave has passed, the wire returns to the passive condition, the current in the connecting circuit ceases and the bundle returns to the initial position. If a series of waves are transmitted over the wire at short intervals, the bundle of capillaries is kept down as long as the periods between the single waves are too short to allow a return to the resting position. In this mechanism the entire portion comprising the connecting circuit should be considered as part of the model for the muscle, the rest of the passive wire representing the nerve.

We have discussed rather extensively the mechanism of muscular action as it plays an important role in the processes of water divining. The discussions in chapter III would be understood with difficulty by a non-physiologically trained scientist unless he was introduced to the fundamental mechanism of muscular contraction.

F. The skin
(see Bibl. No. 533-563)

2. F. 1. Main structural elements of the skin

The animal body is surrounded by a cell-layer called the *skin* or *integumentum commune*, whereas the cavities in the body are covered by a mucous membrane, the *membrana mucosa*.

The membrana mucosa:

The tissue structure is practically the same as that of the ordinary skin. The surface is composed of exfoliated *epithelium cells*, which form together with a fluid secretion a viscous substance, called *slime* or *mucus* All mucous membranes are rich in nerve endings and capillary vessels.

The integumentum commune:

The transition of the mucous membranes which cover the cavities of nose, mouth, etc., into the skin, takes place gradually. The skin serves as a protective layer for the deeper parts of the body. From the centre to the surface it is composed of three main layers (see fig. 22):

a. *Sub-dermal connective tissue*, *subcutaneous tissue or panniculus adiposus* is composed of a layer of cells, connected to the muscles and bones, which possess large meshes filled with fatty substances. In this layer are the larger blood and lymph vessels and nerves.

b. *True skin* or *corium*, a 2-3 mm thick elastic tissue layer, rich in nerve endings and blood vessels, thin near the eyes and thicker at the palms of the hand and foot. It is composed of a wicker-work of skeins of connective tissue and elastic fibres and lies between *lymph cavities* which are connected to the lymph vessels of the subcutaneous tissue. Lymph is a fluid substance which is pressed by the beat of the heart through the blood capillary vessels. It contains practically all blood components except erythrocytes, and has a specific gravity 1.01-1.04 and an alkaline reaction; 1 cm^3 lymph contains abt. 10-20000 lymph cells. Due to this lymph all tissue obtain food substances and the products of combustion are returned to the blood.

Lubricating glands, *the glandulae sebaceae*, occur partly in the corium and partly in the subcutaneous tissue; *sweat glands*, the *glandulae sudoriferae* and the *hair roots* or *folliculus pili*, are composed of three sheaths and are locally penetrated by the lubricating glands. Muscle fibres are connected to the folliculus which, because of cold or nervous excitation, contracts and change the position of the hair in the folliculus (goose-flesh).

The lubricating glands occur only on the hairy parts of the body.

The sweat glands penetrate into the epidermis as corkscrew channels; there are abt. 2.5 million in the human body.

The upper part of the corium contains a great number of bulged

parts, the *skin papillae,* which penetrate into the epidermis. Two kinds of papillae are distinguished: vessel and nerve papillae.

Vessel-papillae contain a network of finest blood capillary vessels, occurring particularly in places with corneous structure (such as nails) which require much blood.

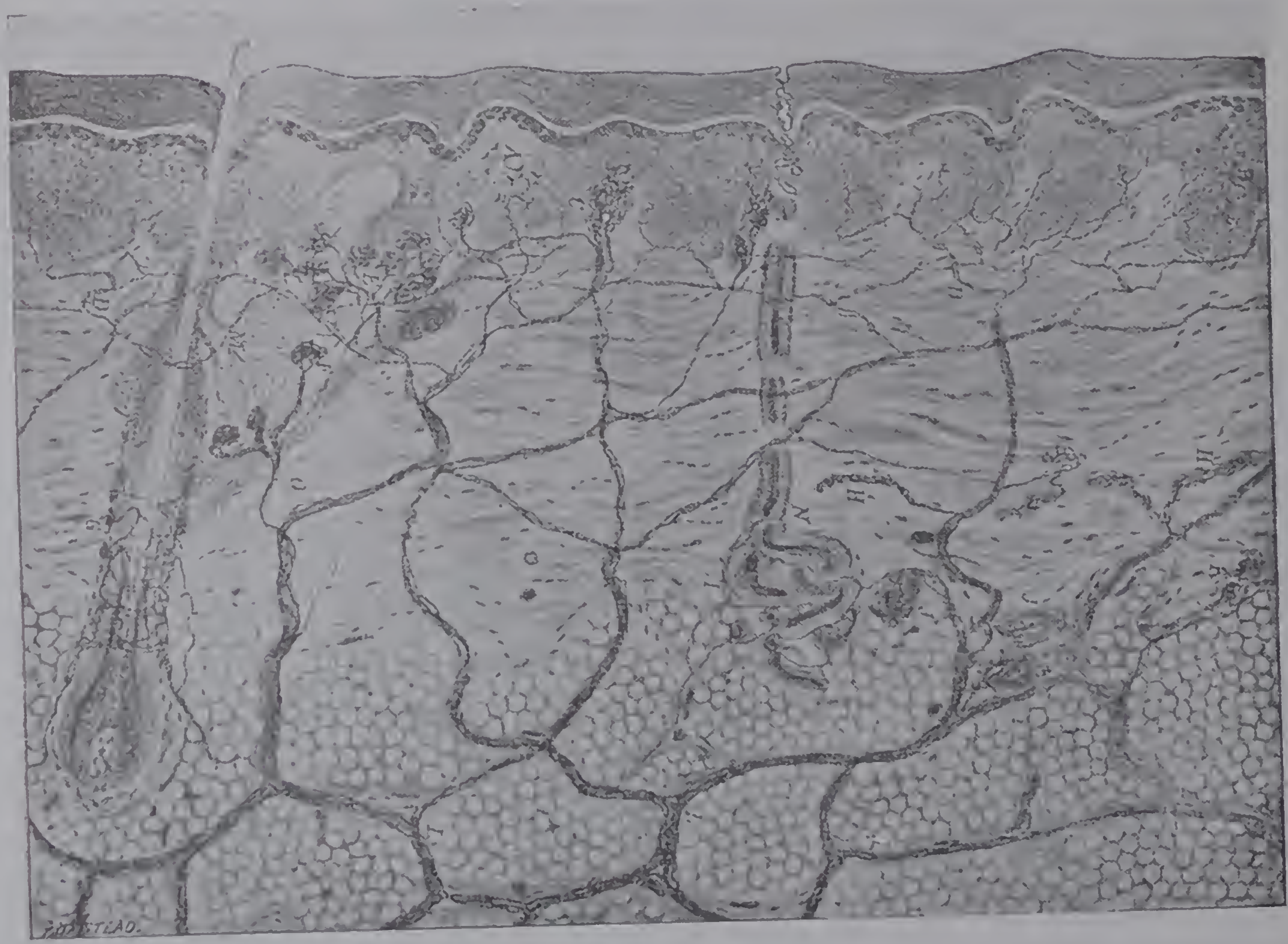


Fig. 22: (Bibl. No. 411, fig. 13) Composite diagram of the structure and innervation of the human skin of the underarm. A. = Merkel's discs, subserving touch; B = free endings, subserving pain; C. = Meissner's corpuscles, subserving touch; D. = nerve fibres, subserving pain; E. = Krause's end bulbs, subserving cold; F. = nerve endings, subserving warmth (sometimes called Ruffini's endings); G. = nerve fibres and endings on hair follicle, subserving touch; H. = Ruffini's endings, subserving pressure; I. = sympathetic nerve fibres innervating a sweat gland; J. = Pacinian corpuscles, subserving pressure; K. = Golgi-Mazzoni endings, subserving pressure; L. = nerve trunks containing thick and thin fibres; M.=Sebaceous gland; N.=sweatgland; O.=sympathetic nerve fibres supplying arrector pili muscle.

Nerve-papillae contain the nerve endings of the sense of touch, etc. (see p. 129).

c. *Upper skin* or *epidermis;* composed of two layers:

1. *Internal layer* or *stratum s. rete Malphigii*, continuously develops new corneous cells by cell division, which move upwards. The youngest and deepest cell parts contain the colouring pigment of the skin, *the melanin*. This pigment activity is vested in specialized cells known as *melanoblasts*. They probably originate in the neural crest of the corium and migrate to the

epidermis; they differ morphologically from the neighbouring *palisade basal cells* by their appearance in vacuolle-like spaces. The influence of radiation on this pigment activity is described on p. 71.

2. *External layer* or *corneum*, which is the most protective layer, is composed of dry cells that swell after wetting.

The epidermis does not contain vessels or nerve endings. It is only a protective layer, practically impervious to fluids because of its corneous structure and the fatty substances of the lubricating glands.

This extensive summary of the structure of the skin is required in order to realize the importance of this protective layer as a medium for transmitting all external physico-chemical impulses (electro-magnetic fields and volatile matter, see p. 32-54 RUSSELL effect) to the blood and nervous systems. Variations in the composition of this protective layer change the nature and intensity of the transmitted energy; the structure of the skin determines also the electric properties of the skin which we discuss in a following section.

2. F. 2. Heat transmission

The process of heat production and heat loss through the skin is discussed extensively on p. 119-120 and can be omitted in this chapter.

2. F. 3. Electric field of the skin

The animal skin is the seat of electric fields which are created by internal physiological and external physical processes. Those fields are either static or dynamic, in the latter case direct or alternating current fields. These different electric fields create electric potentials on the skin known as *skin potentials*. They are extremely important for the health condition of a living organism, as they regulate diffusion, permeability, etc., of the surface membranes. Changes in skin potentials immediately reflect internal changes in the human body and a thorough knowledge of the origin and changes of the skin potentials is therefore required for the study of divining phenomena.

a. *Normal electric field of the skin*

The causes of skin potentials can be summarized as follows:

I. *Static potentials:*

A. Membrane potentials (see p. 17): up to 100 mV.
B. Friction potentials (so-called OPPENHEIM *effect*): caused by friction between different parts of the body and between clothes and the skin (several hundred volts).

C. Dust-potentials: due to electric charges of mineral dust on the skin.
D. Potential gradients of the amosphere: if the body is insulated it will obtain the atmospheric potential; the potential gradient in the atmosphere is abt. 100-200 V/m (see p. 249).

II. *Dynamic potentials:*

A. Direct current potentials or physico-chemical potentials (see p. 17-19).
   1. Diffusion potentials: max. 10 mV
   2. Membrane potentials: ordinary membranes: up to 100 mV monomolecular membranes: up to 900 mV
   3. Alteration potentials: up to 20 mV
   4. DONNAN-equilibrium potentials: few mV
   5. Injury potentials: 20 — 30 mV
   6. Thermo-potentials: few mV
   7. Compression potentials: few mV

B. Alternating current potentials:
   1. Action current of the heart muscles: few mV (see p. 150)
   2. Diaphragm currents: few mV (see p. 152)
   3. Brain potentials: 2-1000 μV (see p. 145)
   4. Electric potentials in the nerve endings in the skin: less than 300 μV (see p. 163)
   5. Action currents of skeletal muscles: 10-200 μV (see p. 162) (HEYDWEILLER-SCHUMANN *effect*)

These different processes have been dealt with in the previous pages, but three processes require further consideration as they play an important role in divining phenomena: friction-potentials, dust-potentials and the HEYDWEILLER-SCHUMANN effect.

Sub I B: *Friction potentials or the* OPPENHEIM *effect* (see Bibl. No. 542a and 543)

A great number of experiments were carried out by OPPENHEIM on the static electricity of the human body, created by the friction between different parts of the body and particularly by the friction between clothes and the skin and between the shoes and the floor. The electro-static phenomena are determined by the equation electric charge (Q) = capacity (C) $\times$ voltage (V). The capacity of the human body to ground was determined by HEYDWEILLER (Bibl. No. 541), SCHWARZSCHILD and BIERMAN (Bibl. No. 539, p. 1469) a.o. It depends on the form and dimension of the body, its internal constitution and its position with reference to grounded objects, but may be taken on the average to be $5 \cdot 10^{-11}$ FARAD (see appendix I, p. 434). The sign of the electric charge depends on the different objects which have come into frictional contact,

being opposite for both rubbed objects. The following list indicates that frictional contact between two substances will make the highest in the table electro-statically positive, the lower one electro-statically negative. According to BOSSCHA the following electro-static range exists at ordinary temperature: cat-skin, ivory, feathers, quartz-crystals, flint-glass, cotton, linen, silk, human hand, wood, lacquer, metals, sulphur. In other words frictional contact between cat-skin and flint-glass makes the cat-skin positive, the glass electrically negative; flint-glass in contact with silk makes the glass positive and the silk negative.

Differences in temperature and composition of these different materials might considerably change their position in the range.

We mentioned on p. 6 the bioelectric phenomena of fish, which are able to develop considerable electric potentials under particularly favourable conditions. Similar phenomena occur with certain human beings and a special study was made in Frankfurt (Germany) by OPPENHEIM, between 1931 and 1933 (see Bibl. No. 543), on the causes of "*telephysical phenomena*", i.e., movements of light objects in the neighbourhood of highly charged electric bodies. OPPENHEIM's observations can be summarized as follows:

1. frictional contact between wool, cotton or silk and the human skin (not the hand) makes the latter usually eletrically positive, the wool or silk clothes being negative. A dressed person as a whole is electrically neutral. An electroscope in his neighbourhood does not show any disturbance. However, if the person undresses and he stands insulated, considerable electric voltages can be registered (few hundred volts) particularly if he moves his fingers near the electroscope. If the atmosphere is very dry, crepitating noises can be heard during undressing, and in a dark room light phenomena can be seen and a neonglowing tube starts glowing. During strong inspiration and expiration alternating glowing phenomena can be observed.

2. High electric potentials are obtained only if the atmosphere is dry, i.e., less than 70% humidity, particularly at abt. 30%.

3. The less the pressure is exerted during the frictional contact the higher is the charge.

4. During the experiments the feet must be insulated (e.g., shoes with rubber soles). If the atmosphere and soil are dry, the insulation of shoes is generally sufficient. Frictional contact between dry rubber soles and the floor in a room with central heating creates potentials up to 800 volts, particularly if one of the feet is lifted from the floor. Very light objects, such as paper cuttings in the neighbourhood move considerably.

5. If a person rises from a chair, considerable electric charges are created on the back of the chair. A piece of silk rubbed against the

leather back of a chair can create several thousand volts. When rubbed against rubber as much as 14,000 volts have been registered by KOOPMAN. Objects up to 2 kg in weight, if placed in a very unstable position, move if the person reaches his hand towards them. The humidity of the atmosphere must be very low in this case (abt. 30%). Very light objects such as paper cuttings, matches might jump in the air.

6. Electric charges of the body or hand can be transmitted to all kinds of objects, both conductors and non-conductors. If a person is insulated and strongly charged by rubbing his shoes and if he holds a glass of water and pours the water into another basin, the bottom of which is connected to a neon glowing lamp, glowing phenomena can be seen.

L. J. KOOPMAN, an electrical engineer, made some experiments in February 1936 in the high-tension laboratory of the municipal power-station in Amsterdam (see Bibl. No. 543). Dr OPPENHEIM was seated in a wooden chair, his feet with rubber soles on the floor, in front of an electrostatic voltmeter. Electric potentials up to 3000 volts were registered during violent movements of his arms. The discharge current amounted to abt. 10^{-7} Ampère, the electric energy up to $3 \cdot 10^{-4}$ Watt (according to KOOPMAN).

URBASCH (Bibl. No. 254, p. 115) pointed out in 1900 that rotation of insulated electro-statically charged bodies causes a deviation of a magnetic needle if placed in its neighbourhood. The rate of deviation depends on the total electric charge and the rotational speed; the direction of the deviation depends on the sign of the electric charge. The rotational direction of a charged plate does not influence the kind of deviation of the magnetic needle.

Prof. HARNACK (Bibl. No. 540) pointed out in 1905 that under favourable atmospheric conditions slight friction between the fingertips and a glass, covering a magnetic needle, can deviate a magnetic needle.

The above-mentioned experiments explain many of the phenomena reported during para-psychological scéances (see Bibl. No. 533 a, 535-538, 544-547, 550-552), such as light phenomena, movements of clothes and light objects in the neighbourhood of the medium. In the 19th century several cases of highly charged human bodies were reported. These were known as "*hommes torpilles*", who showed light phenomena in the dark and were even able to move a magnetic needle. An example is ANGÉLIQUE COTTIN (a well known "electric girl" in the U.S.A., Bibl. No. 550), who appeared to be a genuine para-normal person. It is interesting to note that in the case of EUSAPIA PALLADINO (Bibl. No. 533a) the medium was continuously moving with her feet on the floor; that the experiments succeeded in Italy and in the South of France but failed during rainy weather in England. THERESA PONCI, a girl of 27, living at Confelice near Ravenna (Italy), showed telephysical phenomena, but only if she changed her

dresses. A similar case was reported from a woman in Pirano (Italy). The medium GUZIK (Bibl. No. 537 and 538) showed the phenomena only with rubber shoes, which he moved under the table on the floor.

Cases of so-called "*magnetized water*" (see chapter III) can be explained with experiment 6 of OPPENHEIM.

A moving human body is comparable to a moving electrically charged body. It creates a weak magnetic field, induces electric charges in bodies in its neighbourhood and, when approaching a conductor, the capacity increases (see Appendix I, p. 433), in other words the skin potentials decrease ($Q = C \cdot V$). These phenomena are important for the understanding of divining phenomena (see p. 355).

It is a well-known fact that the greater the curvature of an electrically charged conductor, the greater is the density of electric charge. Near the points of such a conductor the electric charge can flow off by charging the immediately surrounding air and by repulsing this charged air with the point of the conductor. The curvature of the human head, fingers and toes therefore generally possess a greater density of electric charge than the middle part of the body. These phenomena must be borne in mind when we discuss the divining phenomena in chapter III.

Sub I C: *Dust Potentials* (see Bibl no. 534, 542):

CROOK (Bibl. No. 534) developed a method in 1909 for electrostatic separation of minerals, based on the old observation that crystals show electric phenomena (see p. 16). A glass rod rubbed with silk is positive, an ebony rod rubbed with cat-skin or rough flanel is negative. By using both indicators it has been possible to separate electric conducting and non-conducting minerals.

The most important conducting mineral species are the following (g.c. means good conductors easily attracted; m.c. means moderate conductors, attracted with difficulty): actinolite (m.c.), anatase (m.c.), augite (m.c.), biotite (m.c.), brookite (m.c.), cassiterite (m.c.), ferriferous cassiterite (g.c.), chromite (g.c.), diopside (m.c.), glaucophane (m.c.), graphite (g.c.), hematite (g.c.), hornblende (m.c.), hypersthene (m.c.), ilmenite (g.c.), leucoxene (m.c.), limonite (m.c.), magnetite (g.c.), marcasite (g.c.), picotite (g.c.), pyrite (g.c.), pyrolusite (m.c.), pyrrhotite (g.c.), rutile (ferrous) (g.c.), sphalerite (m.c.), titanite (m.c.), tourmaline (m.c.), wolframite (g.c.).

Non-conducting minerals, after heating or because of pressure, possess electric charges (see p. 16) which are different for the different parts of the crystal; e.g., vesuvian after heating is positive at the base and negative at the prism faces; calcite is positive at the end of the principal axis, negative at the secondary axes of symmetry, etc. An electrically charged human body walking in the open is bound to absorb or repulse the electrically charged mineral fragments which occur as dust in the air, particularly if it is a dry day and there is a wind. They are absorbed not only by the skin, but also by the mucous membranes of the nose, mouth and lungs.

Sub II. B. 5: *Heydweiller-Schumann Effect:*

Interesting observations were made in 1902 by HEYDWEILLER (Bibl. No. 541) in the Physical Institute of Münster. He used a *quadrant-electrometer* during his experiments. The needle of the electrometer was electrically charged to a few hundred volts. One pair of the quadrants was earthed, the other pair was connected to an insulated metal plate 15 cm in diameter. The following results were obtained:

1. If one of the hands were placed at a distance of 5 to 10 cm from the insulated metal plate and the trial person placed his feet on an *insulated surface*, considerable negative charges could be observed, which gradually decreased. The total charge and the speed of decrease varied for each person and depended on his mental condition. Temperature, humidity, etc., influenced the final result.

A similar result was obtained in the insulated metal plate if another plate (not the hand) was placed in front of it and if this latter plate was charged from several hundred to one thousand volts.

2. If the trial person bended his knees, the electric charge of the hand was positive and changed to negative after he stood up. This phenomenon could be observed if the person stood on an insulated or non-insulated surface. In the latter event the charges disappeared sooner.

3. Contraction of the upper-arm muscles, opposite the insulated metal plate, created a negative charge in the hand of this arm. If the arm was stretched the charge in the hand was positive.

4. Different parts of the body possess opposite electric charges, which can only be explained by assuming non-conductive parts in a generally conductive skin.

5. Experiments of E. DU BOIS-REYMOND on muscular currents were repeated. During contraction or stretching of the muscles of the arm or leg, electrostatic charges were created, varying between $2\text{-}5 \cdot 10^{-8}$ coulomb. The total energy spent on these electric charges is very small, according to HEYDWEILLER only $2.5 \cdot 10^{-5}$ joule = 250 erg.

In 1928 SAUERBRUCH and SCHUMANN (Bibl. No. 548 and 549) extended the studies of HEYDWEILLER with a compensated string galvanometer and low frequency (200 Hz) amplifiers and confirmed his results. After muscular contraction they were able to register, at a distance of a few metres, considerable electric potentials of the skin, which gradually decreased. Besides this "HEYDWEILLER *effect*", SCHUMANN discovered another electric phenomenon if the trial person remained in a cage of FARADAY. If the arms or legs are moved the mechanical movements of the electric charges in the skin develop rather strong electric fields. Electric fields caused by movements of a single finger or the ankle could be registered at a great distance (SCHUMANN *effect*, see figs. 23 and 24).

ARDENNE (Bibl. No. 533) confirmed the observations of SCHUMANN. He noticed also that the electric fields are very weak if the body is earthed.

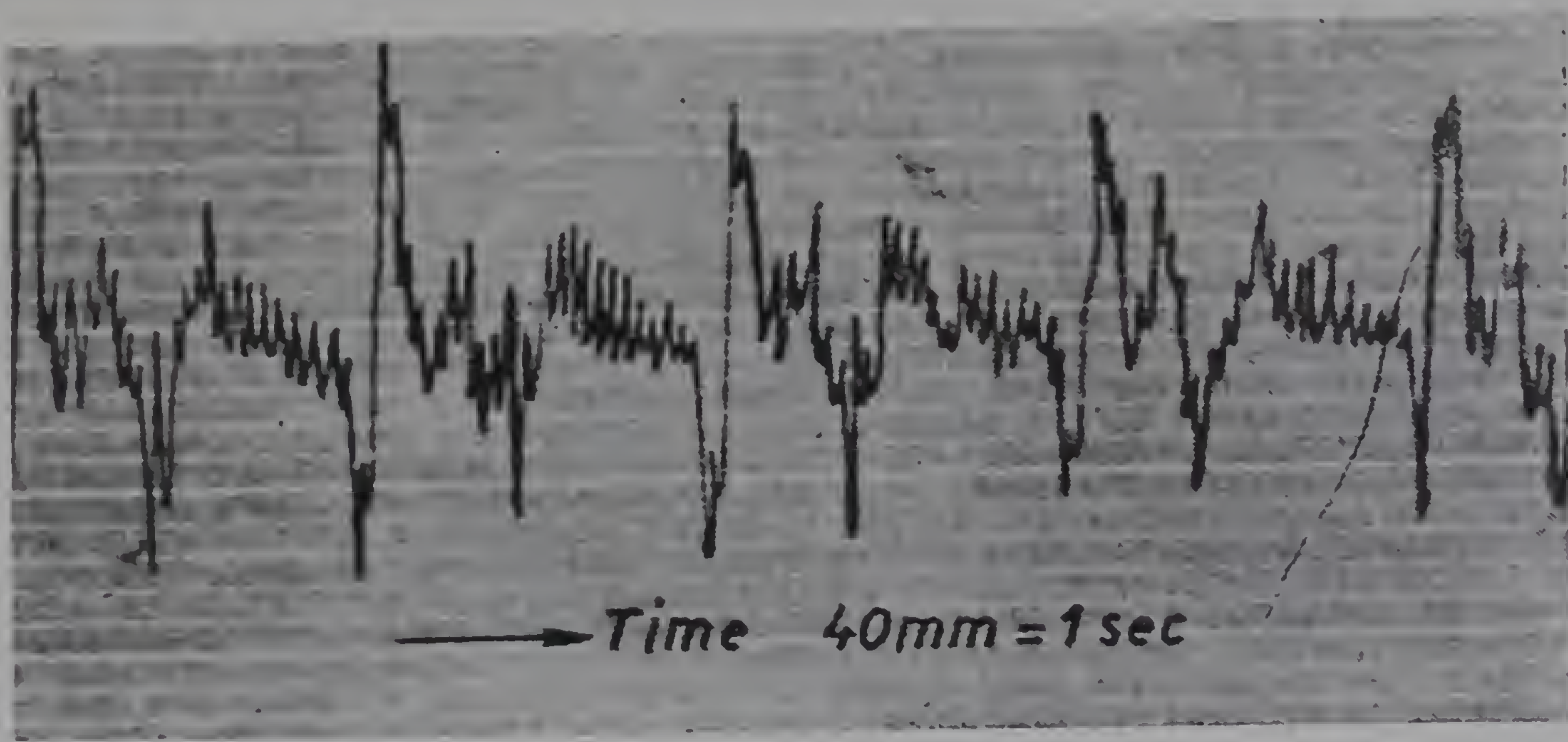


Fig. 23: (Bibl. No. 548, fig. 2) Electric vibrations, created by movements of muscles in the upper part of the body, registered at a few metres distance from a trial person, with a string galvanometer, in a cage of Faraday.

In order to study these fields within a frequency interval of 200-2000000 Hz, ARDENNE constructed a new apparatus with aperiodical multiple tube-amplifiers, which made the whole instrument a thousand times more sensitive. The amplifier was connected to an electrode in a cage of FARADAY, suspended above the head of the trial persons. Brain-waves could not be observed, but muscular contractions on the head were immediately registered. The electric field found by SCHUMANN and ARDENNE are probably not ordinary electrostatic frictional charges. This is indicated by the following observations of ARDENNE:

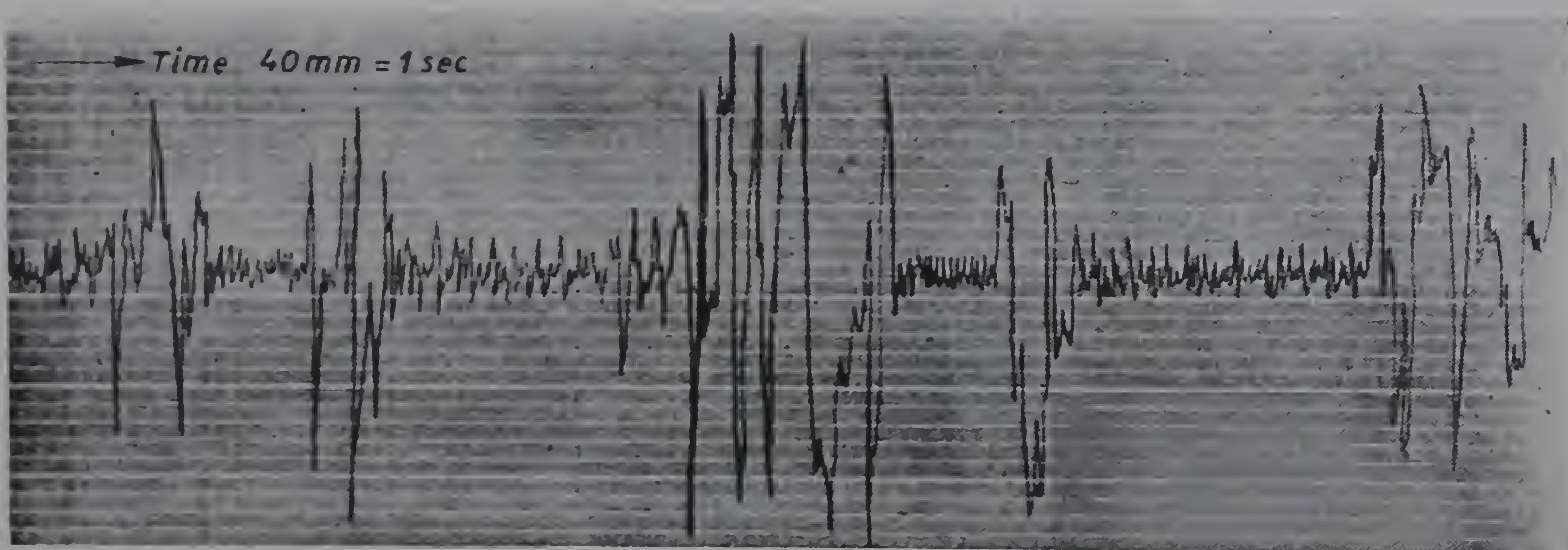


Fig. 24: (Bibl. No. 548, fig. 3) Electric vibrations, caused by strychnine-tetanus of a rabbit, registered at a great distance with a string-galvanometer.

1. the trial person was undressed and surface charges removed by previous earthing; the phenomenon still occurred;
2. rotating brushes or cat-skins had practically no effect on the instrument

3. the influence of the hand is small; the nearer the instrument is placed to the upper-arm muscles the greater the electric effect.
4. the electric charges are particularly concentrated on the skin above the muscular attachments;
5. the electric charges decrease if the trial person tires;

According to ARDENNE and SCHUMANN the basic effects are the result of low frequency electric fields which accumulate into an integral action known as HEYDWEILLER effect.

ARDENNE found that the skin potentials decreased if the skin was wetted with water or during increased perspiration.

Interesting studies on measurements of skin potentials were carried out by J. A. VAN TROTSENBURG (Bibl. No. 551a). Two kinds of experiments were made: in the first group potential differences between two parts of the skin were measured directly by using a triode and observing the variations in the anode current. The observed potential differences were small because of the great electric resistance of the skin. In order to avoid this difficulty TROTSENBURG led an artificial current from the head to the particular part of the skin which he wanted to measure and back again. Because of the potential difference the two currents should be different, depending whether they move towards or away from the head. The measurements were repeated 3 times a day for a week or longer. The following observations were obtained with this second method:

1. When a conductor was placed between the skin of two symmetrical parts of the body an electric current could be measured.

2. The forehead acts always as a negative pole, the periphery of the body being positive; the further we move away from the forehead the greater the positive charge.

3. From two places on the body the one nearest to the forehead is negative with respect to the other place which is further away.

4. The potential differences increase with the distance from the tested places to the central nerve system.

5. Symmetrical places on the body have the same potential, but places on the arm and leg can be found with the same electric potential.

6. The potential difference between the head and periphery sometimes disappears completely, e.g., if a person is examined during deep sleep (without being woken).

7. No potential differences are observed after death.

8. If two needle electrodes are used which are placed in the tissue below the skin and are insulated to such an extent that no contact with the skin is made, no potential differences are observed. If they are placed in the skin, small differences appear. The greatest potentials are obtained by placing the needles on the surface of the skin. In other words, the electric charges are concentrated on the surface of the skin

comparable to the electric charge of an ordinary metal conductor which is also concentrated on the outer surface.

9. The potential difference between head and forearm of the same trial person varies during the day. One would expect the highest value to occur in the morning and the lowest in the evening, but many deviations of this rule were observed even with people who lived very quietly and regularly.

It is evident that the values obtained by TROTSENBURG do not represent the true skin potentials. Only vacuum tube micro-voltmeters, etc., developed by BURR a.o. (see p. 197), might give a correct value.

b. Causes of changes in electric charges and electric potentials of the skin

The causes of changes in the skin potentials are three different factors:

1. changes in the sources of electric fields in the animal body;
2. changes in the physico-chemical properties of the skin;
3. changes in electro-magnetic fields outside the living body.

Sub 1. All factors which influence the action currents of the heart, muscles, etc., also change the electric field of the body. An accurate study of these electric changes must therefore reveal the causes of physiological changes. The experiments of BURR (see p. 198) are a good example of what can be achieved in this new field of research.

Sub 2. The main factors which influence the physical constants of the skin are *temperature* (influencing particularly the sweat glands), *moisture*, *acidity* and *salt content*, the latter three being considerably influenced by the function of the sweat glands. The presence of other substances in the sweat might alter considerably the physical properties and constants of the skin.

Sub 3. External fields can change the electric charges and electric potentials of the skin either directly or indirectly.

α. Electrostatic effects: can change the electric charge of the skin by electrostatic induction, which depends on the electric fields in the atmosphere (see p. 243) and in the soil (see p. 225). The electrostatic capacity and voltage are influenced by the presence of conductors in the neighbourhood.

β. Electro-dynamic effects: can influence the electric charges by changes in conductivity of the atmosphere (determined by moisture, temperature, atmospheric pressure, variations in cosmic radiation, etc.), of the soil (determined by the mineral composition, porosity, moisture, etc.) and changes in the degree of insulation of the shoes.

γ. Photo-chemical-effects of the sun radiation and the *photo-dynamic effects* caused by externally stimulating compounds (see p. 71).

δ. Cosmic radiation, high-frequency waves (see p. 73) near electric power stations, electro-magnetic waves near radio stations, etc., seem to influence, mostly indirectly, the electric field of the animal skin.

ε. *Magnetic fields* can change the skin potentials (see p. 327), probably as a result of induced electric currents.

This short summary indicates the influence of external electro-magnetic fields on skin potentials and as a direct result on the physiological processes creating those skin potentials.

c. *Significance of electro-static fields to the animal body*

It was already known in historic times that strong electrostatic fields could be used in the treatment of certain diseases. At the time of ARISTOTLE and PLINY the torpedo fish, a variety of the electric ray inhabiting Mediterranean waters, was used as a static machine. It was used for gout and treatments of headache. The first electro-therapist was Prof. JALLABERT at Geneva, who effected some improvement in a paralyzed arm by using a machine for the development of electrostatic charges. During medical treatment with static electricity (see Bibl. No. 539) the static machine is preferably located in a room which has plenty of sunshine and fresh air, the air kept very dry by a number of hygroscopic agents. Different methods of application of static electricity are in use:
1. the *static insulation* or *static bath:* the patient is supported on an insulated chair and connected to the positive pole of the electrostatic machine; the negative pole is grounded;
2. the *breeze* or *concentrated brush:* the patient, on an insulated table, is connected to the negative pole; the positive pole is earthed. A grounded electrode is brought near the patient; this creates a concentrated discharge over a limited area;
3. *the static wave:* a specific region of the body of a patient, placed on an insulated table, is connected to the positive pole, the negative pole being grounded.

Other methods are known as *interrupted static wave, direct* and *indirect spark, interrupted insulation*, etc.

If a patient has any metal objects, such as rings, hairpins, etc., near the skin, he will feel a prickly sensation. These objects are therefore removed during treatment. Because of the high potentials the hair stands on end as a result of like charges of hair and body. Duration of treatment is usually 20 minutes.

The static wave has been successfully applied in the treatment of sprains, contusions and other conditions where exudates of a non-infective nature occur (synovitis, tenosynovitis, bursites, myositis), the effect being due to mechanical contraction. Arthritis, tendon sheath infections have also been succesfully treated.

The static brush is employed for treatment of indolent ulcers, facial nerves, subacromial bursitis, fractures (it assists in absorption of extravasated lymph and blood in the injured soft parts).

During the *static bath* the patient experiences a soothing cool breeze; a certain amount of ozone and nitrous oxide is formed. It has been

used as an adjunct in the treatment of neurasthenia, insomnia and nervous headaches.

These medical facts, combined with our previous statements that certain para-normally gifted persons are able to develop very high skin potentials under favourable atmospheric conditions, might explain the reported sensations of people after treatment by such para-normal persons. It is doubtful whether all these reports are only due to suggestion created by the behaviour of a hypnotizer or magnetizer. It must be remembered that patients who ask for magnetizer treatment are often highly strung, i.e., the nerve sensitivity exceeds that of ordinary persons.

d. *Electric resistance of the skin*

General considerations:

The phenomena connected with the electric resistance of the skin are very complicated and are different during application of direct or alternating currents. The opposition exerted by a current to the flow of direct current is called d—c *resistance*; with an alternating current it is called *impedance* of the current. When an electric current flows through a conductor, a magnetic field is set up around the conductor, which opposes the current through *self-inductance*. This opposition is greater to the flow of an alternating current than to direct current. The opposition exerted by a coil due to its inductance is called *inductive reactance*. The quantity of electricity a condenser will hold per volt of applied electric pressure is called *capacitance*. If a condenser were perfect, with no power loss in the dielectric, the only opposition exerted by it to the flow of an alternating current is the *capacitive resistance*. Therefore, if an alternating emf. is impressed on a current, opposition to the flow of current is made up of the actual resistance and the reactance, a result either of inductance or capacitance or of both.

Cole and Curtis (Bibl. No. 553 and 554) have given a mathematical analysis of the resistivity problem. In order to study the resistance or impedance of a part of an organic body they first considered the various component tissues. These tissues in turn are a composite of characteristics of individual cells.

The membrane in the cell and the potential difference across it are of primary importance. Irrespective of the mechanism, the potential difference V, across a unit area of membrane, may be described in terms of its emf., E (maintained by metabolism) and its internal resistance R (depending on ionic permeability). For sufficiently small currents I the Ohm's law $V = E - RI$ can be applied. The phenomena take place *electrically linear* or *physiologically passive*. For larger currents, particularly in an irritable cell, with E or R or both depending on current density, physiological changes occur, the *sub-threshold phenomena* of irritable cells. These phenomena are *non-linear*.

The electric resistivity (r) *of a tissue or cell suspension* for steady continuous current was calculated by Cole and Curtis, after considering the resistivity of different cell models.

$$r = r_1 \frac{(1-\varrho)r_1 + (\gamma + \varrho)\ (r_2 + r_3/a)}{(1 + \gamma\varrho)r_1 + \gamma(1-\varrho)\ (r_2 + r_3/a)}$$

r_1 = resistivity of intercellular electrolyte, Ohm—cm
r_2 = resistivity of protoplasm, Ohm—cm
r_3 = surface resistivity of membrane, ohm—cm²
a = cell radius of major semi-axis, cm
γ = shape factor, equal to 2 for spherical cells and to 1 for cylindrical cells perpendicular to the applied field
ϱ = volume concentration of cells in the tissue or suspension.

If a spherical cell has a protoplasm resistivity $r_2 = 100$ ohm—cm, a membrane surface resistivity $r_3 = 1{,}000$ ohm/cm, a radius $a = 10\mu = 10^{-3}$ cm, the equivalent homogeneous cell has a resistivity $r_2' = 1.0001 \cdot 10^6$ ohm-cm. Under such conditions the current flow through the cell is determined almost entirely by the membrane surface resistivity. A suspension containing 50% by volume of these cells in an electrolyte of resistivity $r_1 = 100$ ohm/cm has a resistivity $r = 249.93$ ohm/cm. If the membranes are perfectly non-conducting $r = 250$ ohm/cm.

Consequently the flow of direct current through such a tissue is primarily determined by the membrane resistance and cell concentration.

A similar calculation has been made for nerves. If r_1 and r_2 are the resistances for a unit of the exterior mediums and interior protoplasm respectively (expressed in ohm/cm), the membrane resistence r_m, the distance between two electrodes = s and R = constant depending on the electrode length, *the resistance of the nerve*:

$$r = \frac{r_1\ r_2}{r_1 + r_2}\ S + \frac{2\ r_1^2\ \lambda}{(r_1 + r_2)\ (R + \cot s/_2\ \lambda)} \quad \text{if } \lambda = \sqrt{\frac{r_m}{r_1 + r_2}}$$

If *sinusoidal alternating currents are applied* the phenomena of inductive and capacitive reactance must be considered. If the surface impedance of the cell membrane = z_m for a small unit area, *the impedance* (Z) *of a suspension of cell spheres* becomes:

$$Z = r_1 \frac{(1-\varrho)r_1 + (2 + \varrho)\ (r_2 + Z_m/a)}{(1 + 2\varrho)r_1 + 2(1-\varrho)\ (r_2 + Z_m/a)}$$

At low frequencies the tissue characteristics are almost independent of membrane reactance and internal resistivity; at high frequencies they become negligible.

Cole gives a summary of measured characteristics of cells: *the internal or protoplasm resistivity* ranges from 30-3,000 ohm/cm, with about 300 ohm/cm for most mammalian cells.

The surface or membrane resistivity of resting cells varies from 100 to

100,000 ohm/cm², the most probable value being 1,000 ohm/cm². *The membrane capacities* vary between 0.4-9 microfarad/cm².

Direct current resistance of the skin:

If a two-volt direct current is applied to the human body a very high resistance is measured which practically disappears if the body is stripped from its skin; in other words the skin is the seat of electric resistance.

Some of the properties of skin resistance are as follows:

1. The resistance changes with the *time* and *direction of applied current*. With anodic current (current entering the body) the resistance increases with the time; with cathodic current the resistance decreases (current increases). By changing the current this phenomenon can be repeated several times.

2. If *the voltage* of a current is increased the resistance first decreases slowly; from 51 V upwards it decreases rapidly and at abt. 500 V it reaches a rather constant minimum, which is also measured on a living body without a skin; in other words this resistance results only from the long electrolytic channel which had to be passed.

3. The skin shows the phenomenon of *electric hysteresis*, i.e.. if the voltage is gradually increased and then is suddenly reduced again, the resistance will remain too small for a considerable time.

4. The resistance changes with the *temperature*, *climate* and *time of the year*, probably as a result of the different structures of the epidermis (see p. 172), its moisture, salt content, acidity, etc.

SCHAEFER (Bibl. No. 556) measured the resistivity of the forearm of a person in summer with a 2-volt current and electrodes with 2.5 cm² surface; he found the value of 800,000 ohm; the same place in winter was 30,000 ohm.

5. REGELSBERGER (Bibl. No. 555 b) discovered a *daily periodicity*. The resistance is in general highest in the morning; it decreases after lunch and increases again in the evening. In other words the resistance curve is parallel to the CO_2 and temperature curves of man. Even if the trial person changes his living conditions (e.g., takes his meals at different hours) similar curves are obtained. REGELSBERGER made extensive studies of the resistivity curves, the *electro-dermatograms*, and considers them related to the function of the vagus and sympathicus.

6. Application of *drugs* considerably changes the electro-dermatogram.

7. We have seen that organic tissue is not physiologically passive if the electric currents increase. This phenomenon is known as *polarization*. It creates a potential opposite to the potential of the applied current and is due to ionic movements and changes in the electric properties of membranes.

8. The resistance varies for different parts of the body. *It is smallest in the centre of the hand palm.* Measurements made by the author with a 4.5 volt current and electrodes of 3 mm diameter indicated that the

skin resistance of the centre of the palm was abt. 15,000 - 50,000 ohm for people sensitive to the divining rod (see p. 328), whereas non-sensitive people have a resistivity of 100,000 up to 2,000,000 ohm. If the resistance is below 100,000 ohm, washing of the hands with water or electrolytes decreases the resistance temporarily below 50,000 ohm. After rubbing the skin with a mixture of salt solution and pumice (see electrocardiogram measurements, p. 144) the resistance drops even as far as 1.000 ohm. However, as soon as the hand is dry the resistance is again high. The resistance of the arm or other parts of the body is generally in the order of magnitude of 10^5 - 10^6 ohm (with the same electrode arrangement).

9. Fluctuations of the skin resistance within a short period are common. According to E. B. HUNT the skin resistance may vary between 15 and 360 ohm. These phenomena belong to the psycho-galvanic reflexes which are discussed next.

10. During deep sleep the skin resistance is very high.

Psycho-galvanic reflexes (see Bibl. No. 557-563):

If a 2-volt current is applied by placing two electrodes at two different places on the skin and the current between the electrodes is registered continuously, a sudden decrease in skin resistance (increase in current) is observed if a psychic reaction is created by calling a person's name, frightening him, etc. This phenomenon is known as psycho-galvanic reflex. Two kinds of reflexes are distinguished:

1. Reflexes created by an artificial current, the *reflex of Veraguth* (Bibl. No. 564). It occurs both in animals and man; it is more widely known in the latter case as *psycho-galvanic reflex*.

2. Reflexes without an artificial current, the *reflex of Tarchanoff* (Bibl. No. 563). The current is created by the difference in potential between two places on the skin, the *rest-current*. A psycho-galvanic reflex can also be obtained in this case.

The psycho-galvanic reflex is characterized by a number of phenomena:

1. A period, known as the *latent period*, occurs between the moment of psychic reaction and the first observable decrease in resistance. After the sudden decrease of the resistance one often observes at the end of the reflex a renewed increase of the resistivity, which might surpass the original value.

2. The psycho-galvanic reflex is not only connected to specific psychic reactions.

3. It can neither be created by purposely controlled muscular contractions, nor prevented by will-power.

4. Atropin and narcotics have a checking effect.

5. Temperature influences both the amplitude and latent period. Increase in temperature from 4° to 45° C decreases the latent period from 3.5 to 1.4 seconds.

6. Hypnotic sleep does not prevent the reflex from occurring.

7. During deep sleep the skin resistance is very high and prevents a psycho-galvanic reflex.

8. Excitation of the tuberal region of the hypothalamus (see p. 131 and 396) seems to create the reflex.

9. Excitation of the sympathicus near the neck causes a decrease of the skin resistance; destruction of this nerve increases the resistance. Sympathically innervated Basedow patients possess a small rest-resistance with strong reflexes.

The cause of the reflex is not yet known with certainty. The fact that the impedance of the skin (with alternating current) remains unchanged suggests that the real resistance does not change during the reflex. Creation of new structures in the skin as the cause of the change in current is also unlikely, considering the great change in resistance. These remains the third possibility, i.e., the counter-acting emf. of the polarized skin could have been decreased, the actually registered emf. and current being increased. The fact that the TARCHANOFF reflex has exactly the same latent period, etc., indicates that the reflex phenomenon and the change in polarization must be due to a change in the cell membranes.

It has been found by LEVA and DARROW that the reflex curve runs parallel to the sweat gland activity. GEORGI observed that no reflexes occurred in a boy born with a lack of sweat glands. These phenomena, together with the influence of the sympathetic nervous system on the skin resistance (see point 9) and the sweat gland function make it feasible that the psycho-galvanic reflex is regulated by the sympathetic nervous system. It is interesting to note that the reflex always occurs together with other sympathetic reflexes such as the pupil reflex (Bibl. No. 558). According to SCHAEFER (Bibl. No. 562) the psycho-galvanic reflex can be considered a special form of nervous cell excitation which changes the electric condition of the membranes.

An interesting extension of the direct-current psycho-galvanic reflex was found during plethysmograph experiments with alternating currents (see p. 188).

Electric impedance of the skin:

GILDEMEISTER introduced, for the first time, alternating currents for the accurate measurement of the true resistance of the skin. Contrary to direct currents, the alternating current does not generally create polarization phenomena in the skin. We have seen on p. 184, that the impedance is practically independent of membrane reactance of the tissues and their internal resistivities. Alternating currents have therefore been used, if accurate resistance measurements are required.

Several investigators (see Bibl. No. 555, p. 341) noticed rhythmical changes in electric properties of the human or animal subject when alternating current of various frequencies are passed through the subject. Recent studies by NYBOER a.o. (Bibl. No. 555 a) on the rhythmical variations in electrical impedance associated with each heart beat, revealed

that these impedance changes are the result of pulsatile volume changes in a given body segment.

It was found also that the mechanical and impedance pulses, registered with an *electric impedance plethysmograph*, are similar when compared with the finger, forearm, etc. An electro cardiogram recorded simultaneously with the electric impedance showed that the maximum impedance occurs just before completion of the Q.R.S. deflection; the impedance rapidly decreases and reaches a minimum almost synchronously with the end of the T-wave. The form of the impedance pulse is modified by artificial mechanical factors influencing the blood flow to a given segment of the body (such as a digit). These observations have been used recently by two Tulane medical school doctors, G. E. BURCH and C. T. RAY, who developed an instrument for registering a man's emotions by "listening" to his finger-tips. No man, however impassive, can keep his finger-tips from palpitating. The subject sticks his finger-tip into a plastic cup and the plethysmograph records the changes in the finger-tip volume which occurs during a psycho-galvanic-reflex.

2. F. 4. Structure of the hand

The surface structure of the hand is of the greatest importance in the study of divining phenomena as a great number of these phenomena (dowsing, radiesthesia) are closely related to certain functions of the hand, which holds either a divining rod or a pendulum. An excellent summary of the importance and functions of the hand is given by JONES (Bibl. No. 541 a), Professor of Anatomy at the University of Manchester. The lines that mark the palmar surface of the hand and the sole of the foot consist of three entirely different elements; the coarser and more conspicuous lines, or *flexure lines*, the lines of intermediate definition, known as LANGER'S, *cleavage* or *tension lines* and the finer markings made up of *papillary ridges*. The flexure lines are used in fortune telling (*cheiromancy*) and the papillary lines in *dactyloscopy*.

The flexure lines and creases (see figs. 25 and 26) are the result of tangential tensions in the skin tissues, which are mainly determined by the distribution of forces, i.e., the different nerve endings in the hand. It can be proved that the lines are not the result of working or simple folding of the hand: 1) the lines are always deeply marked at birth, whereas later work might cover up part of the lines with a thick layer of callosity; 2) lines are found on places in the hand where no folding occurs; 3) certain diseases, such as paralysis, might cause the disappearance of lines, whereas those parts of the hand are still folded. In other words, flexure lines are directly or indirectly reflexions of a certain distribution and function of nerves. It is therefore logical to assume, that a certain brain can have only a certain pattern of forces on the hand connected to that brain, and therefore the markings of

two hands can never be alike. Even hands of twins are widely different. Nonetheless, in certain families a certain peculiarity in the hand might run through generations just as a characteristic nose, chin or mouth.

Fig. 25: (Bibl. No. 541a, p. 82). The crease lines of the hand. A, B, C, the distal, medial and proximal digital creases. D and E, the distal and proximal transverse palmar creases. F, G, H, the radial, medial and ulnar longitudinal palmar creases. K and L, the distal and proximal bracelet creases.

The two hands of one and the same person are also different, although in a smaller degree than the same hands (for example, both left hands) of two different persons. There are several reasons for the difference between the left and right hand of the same person:

1. A human being is not completely symmetrical and the distribution of the tensions round the nerve centres is not therefore the same in both hands; thus the folds in the skin cannot be equal.

2. The left side of the human body is ruled by the right part of the brain, the right side by the left part. As those two parts of the brain are not equal, the electric tension caused by them in the left and right hand must also be different.

3. As most people are right-handed, several changes are created in the right hand after birth, changing in turn the original pattern of the hand. Palmists assumed that the lines of the left hand reflect only the constitutional tendencies, whereas the right hand reflects the resultant of acquired and constitutional tendencies. They used to say: "the greater the difference between left and right hand, the more interesting and eventful the life of that person."

Fig. 26: (Bibl. No. 541a, p. 96) The palm of the left hand of a young female chimpanzee showing the flexure lines.

Further evidence for the importance of the lines of the hand can be found in the criminal auxiliary science *dactyloscopy*. The small creases on the fingers and thumb create the finger prints which are characteristic of each person. This was known to the Chinese some thousands of years ago. A mother who abandoned her baby never forgot to take the finger-prints which enabled her later to claim the child from the foundling-hospital. The results obtained by different institutes for criminal investigation are further empiric proofs that a certain association of finger-creases belongs only to one and the same human being and must therefore reflect a certain distribution of nerve-centres, characteristic of that particular person.

The *flexure lines* are the surface registration of the mobility of bony parts (see fig. 27). They mark the site on the hand which is brought into action by the movement of the underlying bony joint. Fig. 25 explains the main flexure lines in the hand of a man; fig. 26 shows the same lines in the palm of the left hand of a young female chimpanzee; fig. 27 indicates the relation of the flexure lines to the bony elements.

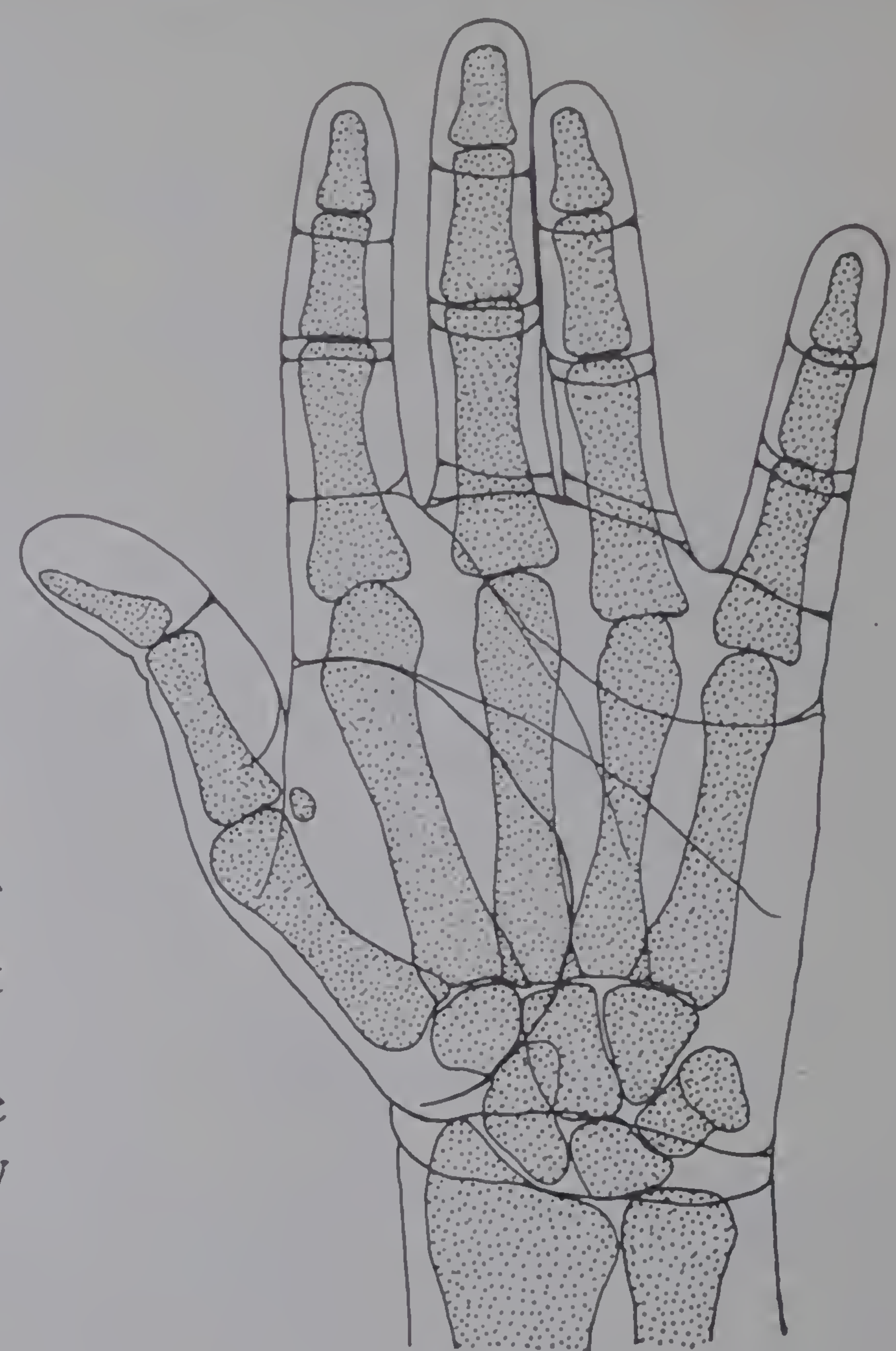


Fig. 27: (Bibl. No. 541a, p. 94) The relation of the flexure lines to the bony elements of the hand.

Apart from the system of flexure lines the *tension lines* occur; these represent a much finer series of skin markings arranged as small wrinkles running in the long axis of the digit. They give a definite texture to the skin surface of the hand. Upon the palmar surface the flexure lines

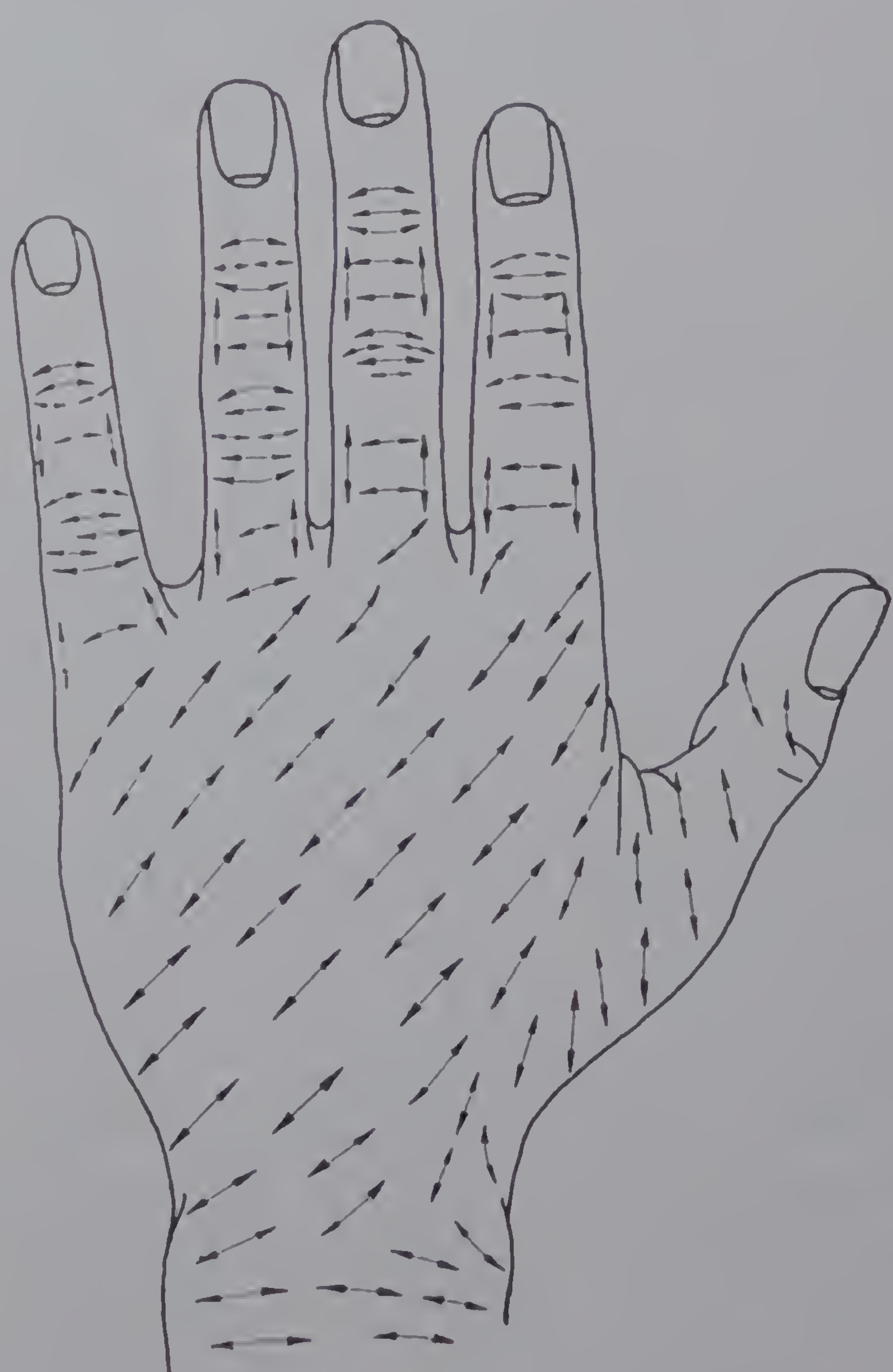


Fig. 28: (Bibl. No. 541a, p. 103) The cleavage lines of the dorsum of the hand (from LANGER's charts, modified by Cox)

and papillary ridges mask this surface texture, but towards the wrist the finely wrinkled pattern reasserts itself.

DUPUYTREN and LANGER could prove that these tension lines are actual cleavage lines if a sharp object is pierced through the skin. The tension lines are therefore called *cleavage* or LANGER'S *lines*. Fig. 28 and 29 indicate the distribution of the cleavage lines on the dorsum and palmar surface of the hand. They are determined by the direction of the strands of dermal fibrous tissue. Cox made a special study of the structure of the skin near the cleavage lines. Fig. 30 shows a section cut along the axis of the cleavage line; fig. 31 is cut at right angles to it.

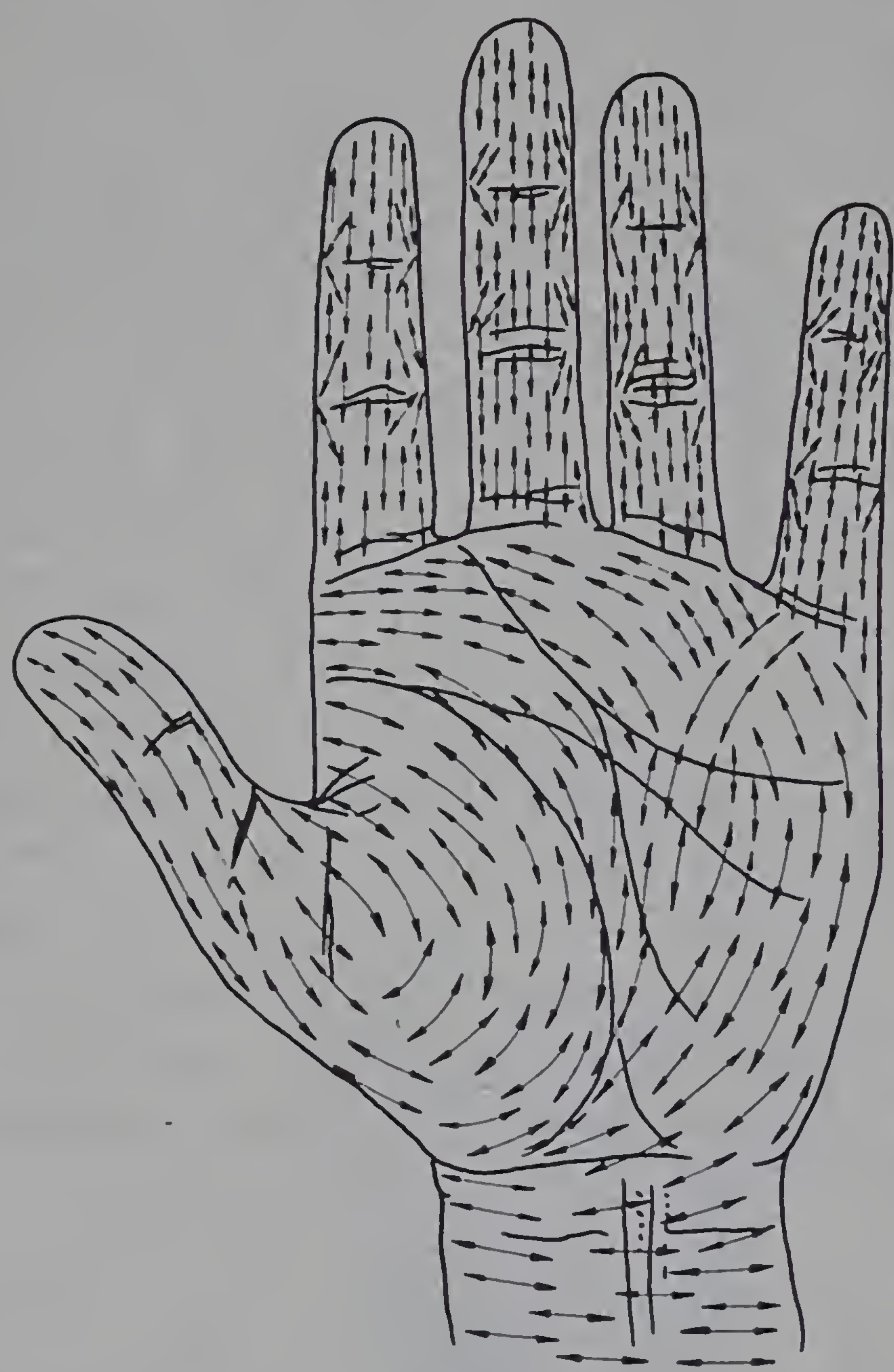


Fig. 29: (Bibl. No. 541a, p. 105) The cleavage lines of the palmar surface of the hand (from LANGER'S charts, modified by Cox)

The *papillary ridges* on the fingers are composed of linear thickening of the horny layers of the epidermis, separated from its neighbours by an epidermal depression. Below each ridge there is a corresponding thickening of the epidermis, in other words, a papillary ridge is a thickening both above and below the general surface of the skin, the function being to improve the tactile grasping surfaces of the fingers. The sweat glands open in regular linear series along the summit of the ridge. The first classification of papillary patterns appeared in 1823 by PURKINJE, which was applied scientifically in dactyloscopy in 1880 by Dr HENRY FAULDS. A re-examination of a large number of prints over a period of 30 years convinced Sir J. HERSCHEL and GALTON that from birth to death there is no change in the fundamental characteristics

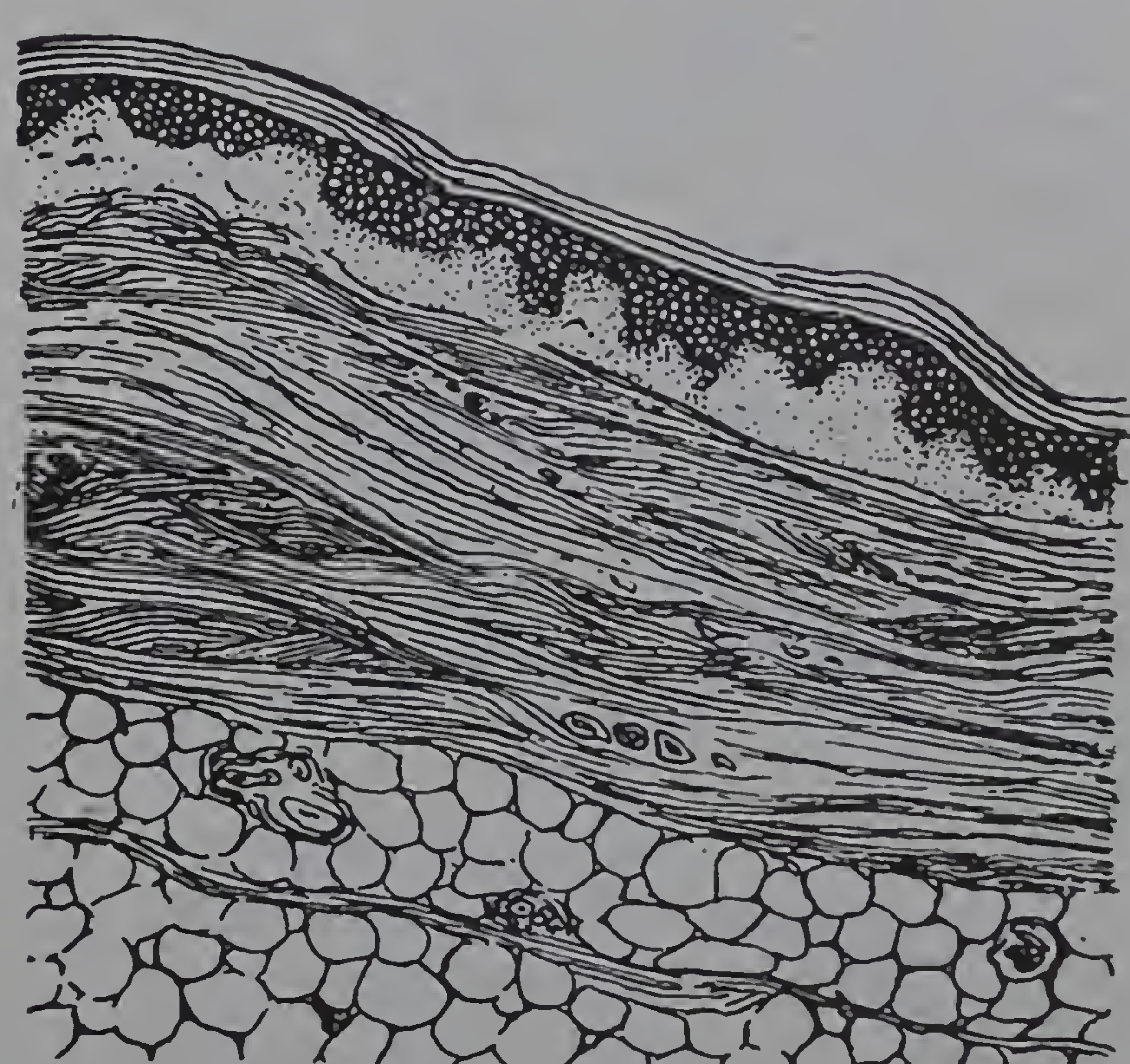


Fig. 30: (Bibl. No. 541a, p. 106) Section of skin cut in the axis of the cleavage lines (from a preparation by Cox)

of the thumb and finger patterns, nor can there be any changes after death up to the time when decomposition takes place.

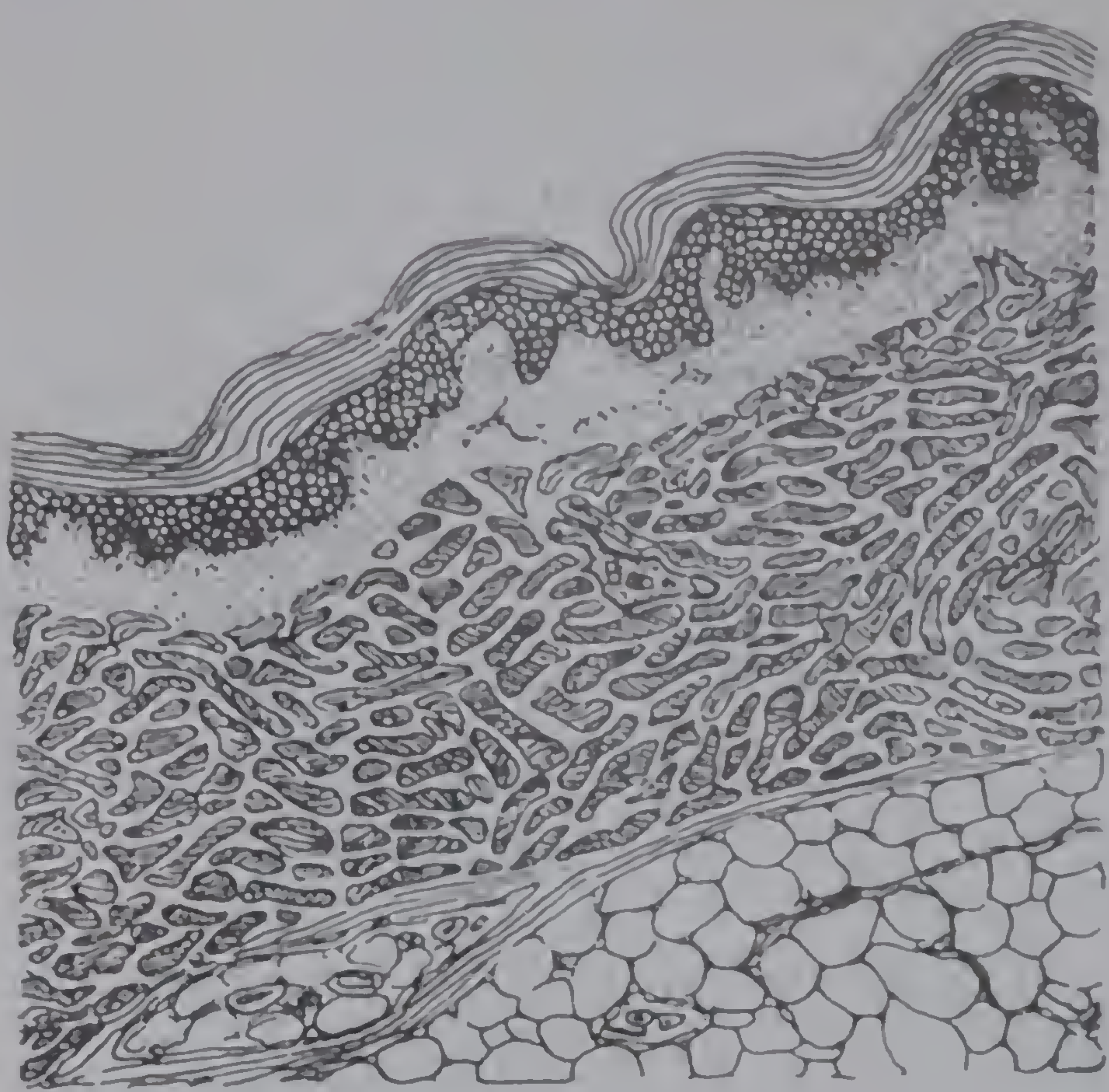


Fig. 31: (Bibl. No. 541a, p. 107) Section of skin cut at right angles to the axis of the cleavage lines (from a preparation by Cox)

FORGEOT and WILDER claim that inheritance plays a definite role in the disposition of the papillary ridges; also, occur according to the studies of ALEX (1868) and KOTANDO HASEBE, well-marked racial variations. It has been found that the whole system of ridges is established before the foetus has lived half its interuterine life.

So far we have considered only the surface structure of the hand. Below the skin lies the *fascias* (see fig. 32). It is composed of tissues of low organization which remain undifferentiated when other structures acquire their definite specialisation, e.g., the muscles, when developed in the embryonic limb, are differentiated in the midst of a mass of tissue, some of which remains undifferentiated around each specialized muscle mass.

The undifferentiated tissue between each muscle fibre in the hand is called *endomysium*, between the collected group of fibres *perimysium*, and around the whole muscle *epimysium* or muscle sheath. The fascias of the hand comprises therefore the fibrous tissue sheaths of all the muscles, tendons, nerves, vessels, bones and joints. It is divided in the *superficial fascia*, i.e., the fat-containing subcutaneous tissue (see p. 171) and the *deep fascia*, a general dense ensheathing envelope for the muscles and tendons of the hand.

Fig. 32: (Bibl. No. 541a, p. 163) The fascias of the palm of the hand.

The muscles of the thumb and little finger constitute two well-defined groups which act on these

two digits alone. They are separately wrapped in fascial envelopes. The thenar and hypothenar muscles are separated by two *septa* from the central compartment of the hand. The internal and external intermuscular septa divide the tissues of the palm of the hand into three compartments, the *thenar space*, the *middle palmar space* and the *hypothenar space*. The relationship of the two first and most important spaces to the bones and crease-lines of the palm is indicated in fig. 33.

An important part of the hand is formed by the *vascular channels*, which carry the blood and lymph in the tissues of the hand. There are

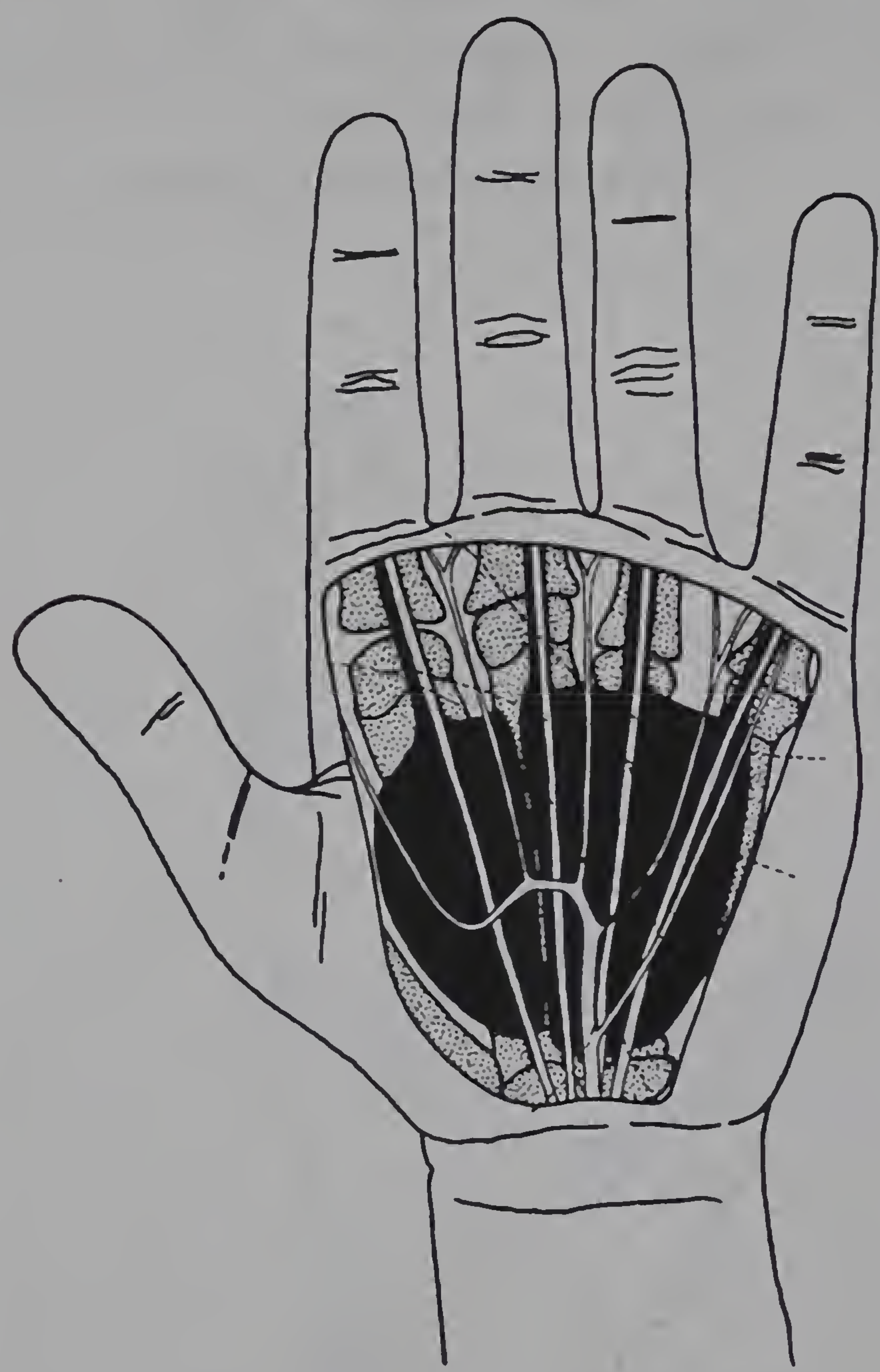


Fig. 33: (Bibl. No. 541a, p. 170) The thenar and middle palmar spaces (in black) shown in relation to the bones, crease lines, etc., of the palm.

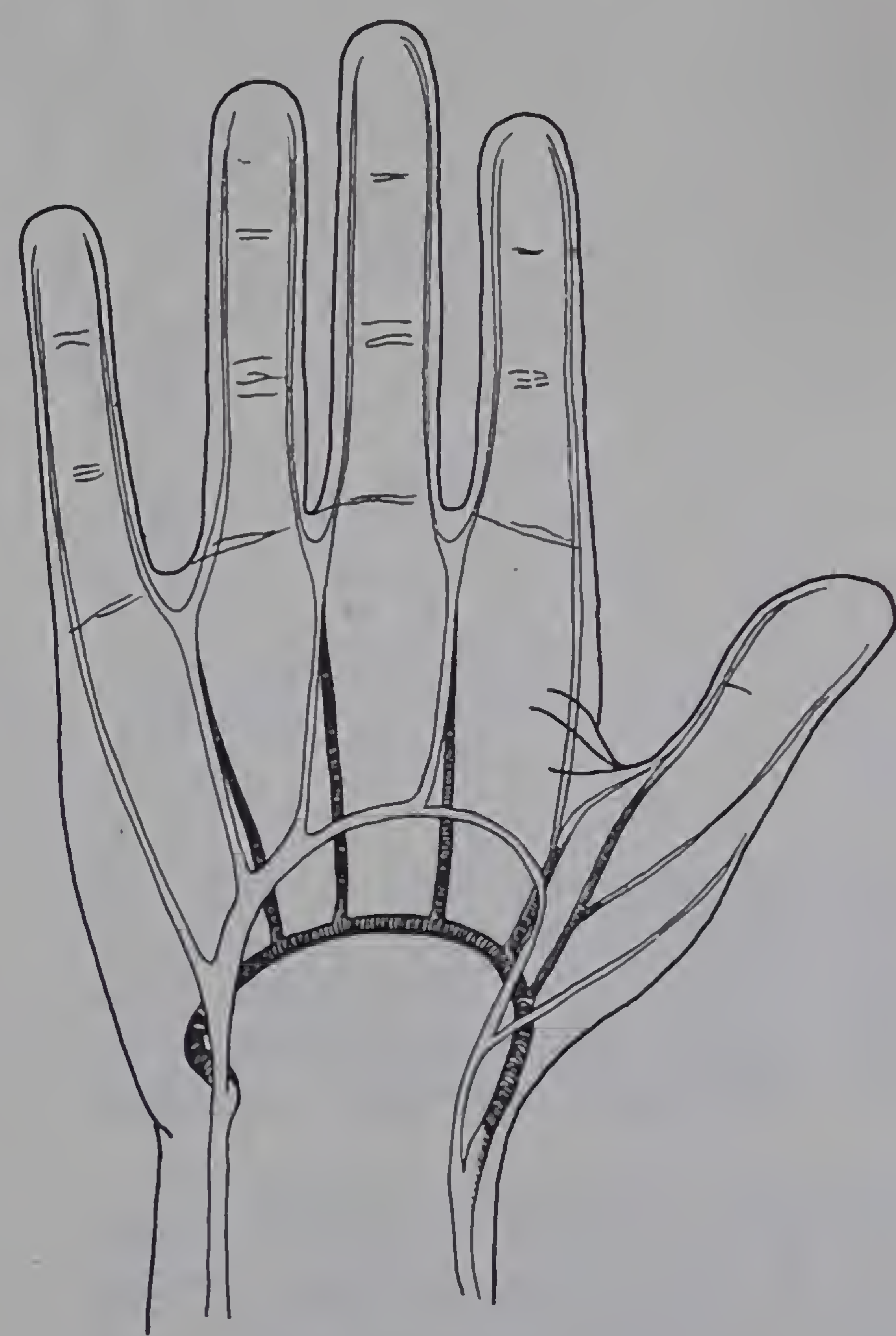


Fig. 34: (Bibl. No. 541a, p. 377) The deep and superficial palmar arches.

two important channel systems in the palm of the hand, known as *superficial* and *deep palmar arches*. The former lies superficial to the long flexor tendons and is derived mainly from the ulnar artery in the fore-arm. The position of the deep and superficial palmar arches is indicated in fig. 34.

The previous summary of the main structural elements of the hand shows how complicated any accurate physical treatment of the electric phenomena in the hand must be. It also explains how little is known of the actual processes in the hand after electric stimulation. This problem becomes even more complicated if the distribution of nerves is taken

into consideration. In the study of the hand only three nerves are of great importance: the *musculo spiral nerve*, the *ulnar* and the *median nerve*. The *musculo spiral nerve* is constituted by the 6th, 7th and 8th cervical nerves. It is one of the posterior or dorsal branches of the *brachial plexus*, and is destined for the motor supply of the extensor muscles of elbow, wrist and fingers and for the sensory supply of the extensor surface of the limb.

Fig. 35: (Bibl. No. 541a, p. 357) The distribution of the ulnar nerve in the palm of the hand. The nerves beset with Pacinian bodies are sensory branches, the shaded branches are motor.

The *ulnar nerve* is a mixed nerve, containing motor fibres for certain of the flexor muscles of the wrist and fingers and for many of the intrinsic muscles of the hand, as well as serving as a sensory nerve for the ulnar side of the hand. It derives from the caudal end of the outflow of the fore-limb nerves and only the 8th cervical and 1st dorsal nerves enter into its composition. Fig. 35 indicates the distribution of the ulnar nerve, with the Pacinian bodies (see p. 129) in the hand-palm.

Fig. 36: (Bibl. No. 541a, p. 363) The distribution of the median nerve in the palm of the hand. The nerves beset with Pacinian bodies are sensory branches. The shaded branches are motor.

The *median nerve* is the most important of the three. Its distribution in the hand-palm is illustrated in fig. 36. It is composed of fibres coming from the 6th, 7th and 8th cervical nerves as well as from the 1st dorsal. The nerve is a mixed one subserving all forms of sensibility and

supplying motor neuraxons to the pronator-flexor group of muscles.

This short summary explains the fact that more nerves are developed between brain and hand than almost any other part of the human body. Tendencies, such as anger, affection, fear, etc., are immediately shown by movements of the hand. One can almost say that the brain cannot think without the hand being influenced by the thought.

Interesting experiments on the sensitivity of the hand were made by MARSHALL, WOOLSEY, and BARD (see fig. 37). During light tactile stimulation of various parts of the palmar surface of the right hand of

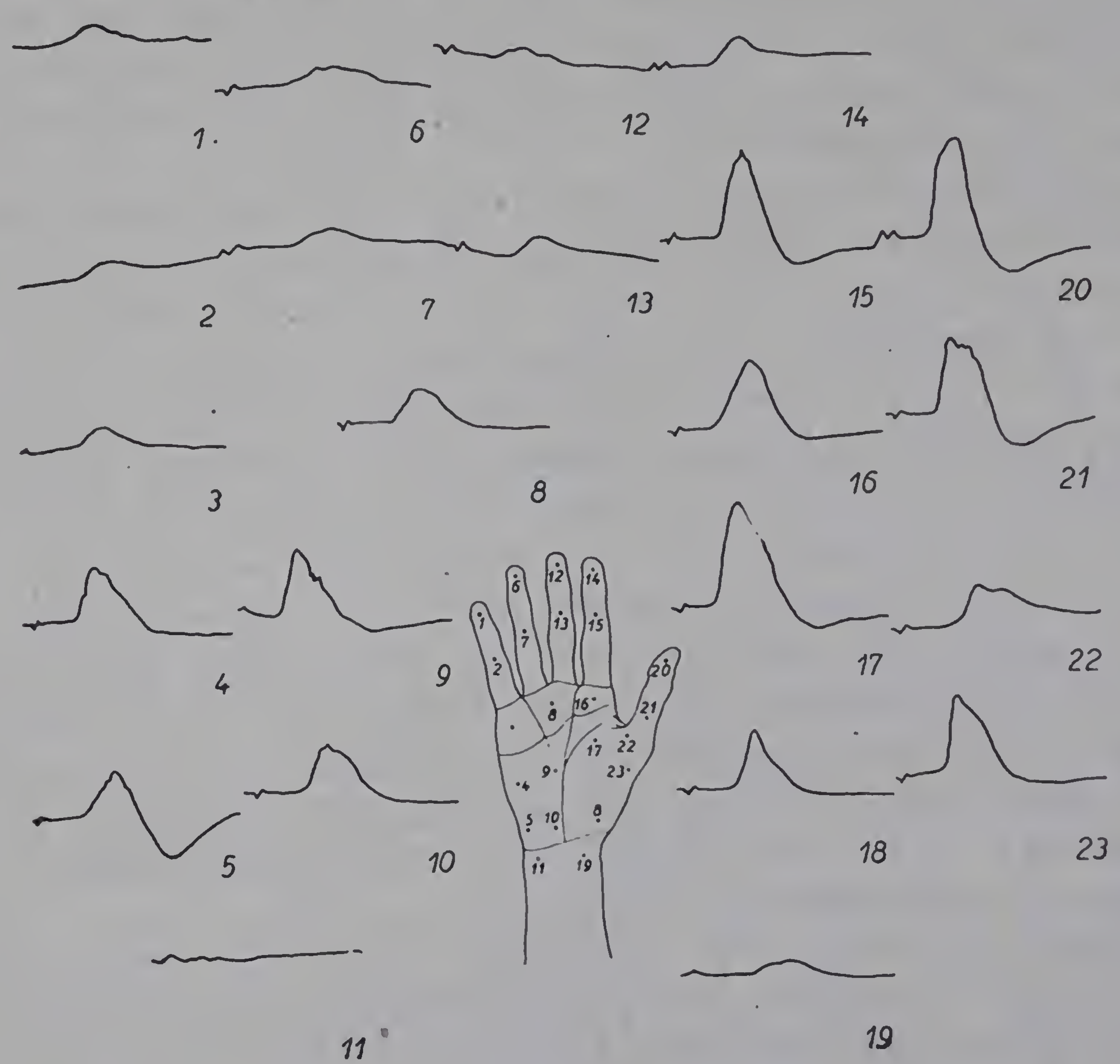


Fig. 37: (Bibl. No. 513, p. 210) Surface positive potentials recorded from a single spot in the hand area of the left post central gyrus on light tactile stimulation of various points on the palmar surface of the right hand. Max. responses from thumb and adjacent surfaces of palm and index finger (after MARSHALL, WOOLSEY and BARD).

a monkey, electric potentials, created in two electrodes placed in contact with the somesthetic area and the occipetal cortex, were recorded with a cathoderay oscillograph (with amplifier). From the curves in fig. 37 it can be deduced that maximal responses were obtained from thumb and adjacent surfaces of the palm and index finger. It is interesting to note that the same zone has the lowest electric resistance of the palmar surface. Both observations are very important for the study of divining phenomena as a dowser holds the divining rod on these places of the palmar surface (see chapter III).

The difference between the hand of man and the monkey is not

so much the result of anatomical differences as the result of the perfection of the human brain. Voluntary, purposeful movements are initiated in man, as we have seen on p. 132, in a definite region of the cerebral cortex, known as the *rolandic, pre-central or motor area* (see fig. 10). The grey matter in this region of the cortex consists of quantities of nerve cells, among which are the motor cells, *giant pyramidal cells of Betz* or *ganglionic cells of Bevan Lewis*. These nerve cells are the largest found anywhere in the cerebral cortex, and in general shape they vary from conventional "pyreform" to "pyramidal." Each cell gives rise to several lateral processes as well as to an apical dendron that passes to the surface layers of the cortex and a great axis cylinder that runs straight from the surface of the cortex towards the centre of the brain and thence to the spinal cord.

In many non-mammalian vertebrates, e.g., birds, the motor area is moved towards the spinal cord. Removal of the brain does not prevent coordinated muscular movements as would be the case in man. Although movement in lower animals (e.g., dogs) seems to be initiated sub-cortically as a kind of *reflex* at a lower level of the central nervous system (i.e., in the *corpus striatum*), in higher animals (e.g., Simiadae) it is becoming *re-represented* in the cerebral cortex and it is beginning to share in the great advances of cortical control. In man this process has proceeded further than in any other animal and *in this process of cortical re-representation lies perhaps one of the most wonderful adaptations that have come about in the evolution of mankind* (Bibl. No. 541a). The re-representation in the cortex, which is associated with memories from other brain sources, *makes the animal conscious* of what the moving parts of the body are doing. The *experience* of the animal *leads to perfected modification* of these movements as circumstances demand.

The problem of sensitization of diviners is probably related to these phenomena of re-representation and training (i.e., experience). In man only the cortex is the initiating mechanism; the corpus striatum has ceased to be a motor nucleus as far as voluntary movements are concerned. In a growing baby the cortical function is gradually developed; this, according to JONES a.o., consists of recording of "*action patterns*" that represent the pictured movements of practically every moving part. Temporary loss of these "action patterns" in man might cause "*hysterical paralysis*." Many para-psychological problems are probably related to "action patterns."

There are certain movements of which man has no sort of pictured conception, e.g., movements of the viscera, heart or intestines. The initiation of such movements is still lodged in the lower centres of the brain-stem or spinal cord.

This summary of the structure and the mechanism of the muscular movements of the hand might enable the non medically trained natural scientist to evaluate the physical processes that occur during the divining phenomena in the hands of para-normal persons.

3. Electric field of animals

(see Bibl. No. 565-583)

We have discussed in the previous pages the bioelectric phenomena in general (p. 5-8) and the electric field of man (p. 8-196). We now deal with the electric field of animals. In general it can be stated that the electric phenomena of man and animals are more or less the same. The differences are more quantitative than qualitative.

The existence of potential gradients or rather steady state potential differences in living systems has been known for more than 100 years. However, consistent reproducible measurements were difficult to obtain as all measuring devices were current drain instruments; in addition techniques for connecting the measuring devices with the living system introduced uncontrollable artefacts, due to contact potentials.

Modern instruments for measuring bio-electric potentials are based on the following principles:

1. the input impedance must be high, i.e., a minimal current should be drawn from the tested object;
2. the device must be of high sensitivity; potential differences of 10 μ volt must be measurable;
3. the device must have stability;
4. the instrument must be completely independent of external electric disturbances, whereas the specimen must remain unshielded;
5. it must be possible to read off the instrument potential differences in μV;
6. sensitivity of the device must be independent within wide limits of the resistance of the specimen under test; this is related to 1;
7. the instrument must be readily portable;
8. standard radio parts must be used to keep the cost at low figure.

Different instruments have been developed of which the most important are described in bibl. No. 569, 575, 577, 578, 582, 594, 595, 602. The most perfected instrument was built by Burr and Northrop (see Bibl. No. 569 and 578), and developed after 7 years' experimental work; it was based on the circuit designed by Wynn-Williams. As radio tubes, the power triode no. 112 A or IG4 was chosen, as it has a large transconductance, is a non-heater type with relatively low temperature filament and low plate impedance. To eliminate grid currents the principle of floating grid was applied. Silver-silver chloride electrodes were used, supported in such a manner that they do not exert any pressure on the measured surface.

As a result of thousands of accurate measurements on animals and plants Burr (Professor of Neuro-Anatomy at Yale University, U.S.A.) and his collaborators found that there is a relatively steady state of voltage difference between any two points of a living body. The gradients are remarkably stable and are changed only by alterations in fundamental biological processes, such as growth, injury, sexual

activity, cancer, etc. *The standing potentials in the living organism define the electro-dynamic field, which fundamental pattern determines the organization of the living being and reflects in significant ways its fundamental biologic activity* (see Bibl. No. 568 and 572). This electro-dynamic field appears to control and regulate the development of every component part of a growing biological system; *the various successive steps in ontogeny are therefore not causally related links in a chain of events, but are common expressions of a single regulating electro-dynamic principle* (see Bibl. No. 567 and p. 126, laws of cell-developments.).

The most important results of the experiments of BURR are as follows:

1. *Cell-growth*:
   a. There is a slow but progressive change in voltage pattern concomittant with growth and development of animals and plants;
   b. The magnitude of the voltage gradient seems to be related to the rate of cell division;
   c. The standing potentials in the frog's egg exhibit a pattern present in the non-fertilized egg which continues through fertilization, segmentation and gastrulation, the axis of the pattern being correlated with the longitudinal axis of the embryo (see p. 15 and 398 and Bibl. No. 574);
   d. Characteristic changes in the electric pattern were found to be associated with various neoplasms in mice and human beings (see Bibl. No. 573). BURR, SMITH, and STRONG have recorded the observation that in genetically controlled strains of mice, spontaneous adeno-carcinoma of the mammary gland can be recognized by a marked rise in voltage gradients across the chest 2-3 weeks before it is evident as a result of palpation;
   e. According to BURR a.o. (Bibl. No. 567) regulating influences of the electro-dynamic field could be established. These are created by rapidly dividing cells of Amblystoma, on the growths of axis cylinders of the sensory cranial nerves.

2. *Wound healing*: The reparative process in wound healing seems to be associated with a characteristic series of electric changes. There is also a rough correlation between the degree of pathology and magnitude of voltage differences.

3. *Sexual cycle*:
   a. It was found by BARTHON (Bibl. No. 565) and BURR (Bibl. No. 572) that a marked and significant rise in the voltage gradients between the index fingers in women occurs at reasonably regular periods in the menstrual cycle, a conclusion based on 50 trial persons and 224 menstrual cycles. This voltage rise lasts about 24 hours and is probably associated with ovulation. It was already known that the menstrual cycle depends on variations in the rate of secretion of ovarian hormones, such as *theelin* ($C_{18}H_{22}O_2$),

which is regulated mainly by the hypophysis (pituitary glands) (see p. 396). These hormones increase the growth of the Graafian follicle, causing an excitation of the nerves in the ovary which in turn creates an increased blood circulation and bursting of the follicle. It is of interest to observe that this process is reflected in the whole blood stream and the skin potentials.

b. Rabbits showed a significant change in the voltage gradient between the vagina and the symphysis at the time of ovulation, with significant peaks occurring at the time of follicular rupture as observed under the microscope (see Bibl. No. 568 a).

c. It has been found that at least once in the majority of menstrual cycles of women, the potential difference between the cervix uteri and the ankle, being usually positive, becomes negative for 24 - 28 hours. In 2 instances artificial insemination at the time of negative shift resulted in pregnancy. Characteristic changes in the vaginal smear occur shortly after the negative shift and pregnandiol appears in the urine 48 hours after its occurrence.

4. *Polarity phenomena*:
Voltage gradients can be measured, because of different electrical potentials of the upper and lower part of the body, between the head and tail of amblystoma and chick embryo. This can be done, not only if contact is made with the skin, but even when the electrodes are 2 mm away from the surface (see Bibl. No. 572).

5. *Further evidence for an electrodynamic field* (see Bibl. No. 572). BURR discovered that a salamander embryo, revolving between capillary electrodes, creates an oscillatory current in a recording instrument. The same occurs if a free swimming larva rotates. A copper rod with a piece of solder at one of its ends creates a similar alternating electro-magnetic field. A rotating glass-rod, however, did not produce any effects.

Potential measurements were carried out by KELLER, DEJDAR, and HALIK (Bibl. No. 575, 576 and 580) in the Zoological Institute, Prague. They used a tube potentiometer of FÜRTH and protein electrodes with a diameter of 0.699 mm. The following results were obtained:

1. The potential difference between the skin of a frog and surrounding water varied considerably for different places of the skin, both in sign and magnitude. The max. values amounted to abt. 80 m. Volt.
2. Similar measurements between the gill epithelium of Amblystoma Tigrinum Green and water indicated potential differences of 17 - 18 m. Volt, the epithelium being negative; the gill stems are electrically positive; the potential difference between gill, epithelium and stem amounts to abt. 15 mV, the epithelium being negative.

Other experiments on the electric field of animals can be found in Bibl. No. 577, 579, 581-583.

4. Electric field of plants

(see Bibl. No. 584-604)

A great number of experiments have been carried out on the electric field of plants. They indicated that relatively steady potential differences occur on the surface of plants. These are related to the form (BURR), the polarity phenomena (WENT a.o.), growth, etc.

1. *Injury potentials* (see also p. 19):
   a. KÜMMEL (Bibl. No. 600) studied the potential differences of two points on the leaves of plants before and after injury. The first value was deducted from the second. In the case of *acacia* the max. pot. difference shortly after injury amounted to —32 mV; after 1 hour to —8 mV; after 24 hours to —24 mV. The same observations with *fuchsia corymbosa* gave the values —68 mV, —23 mV and + 52 mV; with *lupinus albus* —120 mV, —4 mV and —29 mV.
   b. During repeated injuries the same negative values were more or less always obtained; they decreased, however, after a few days.
   c. The negative values, in case of succulenta, decreased with increasing pH and decreasing concentration of the plant saps.

2. *Electric potentials on amoebae* (see also p. 53, Electrophoresis):

   Although several biologists are inclined to consider the amoebae as belonging to the animal protozoa, many botanical textbooks include these primitive living bodies in the world of plant life. We have followed this latter classification.
   GICKLHORN and DEJDAR (Bibl. No. 595 and 596) studied the electric potentials of Pelomyxa palustris Greef, amoebae with a diameter of 1,000 - 2,000 μ. They are composed of a mass of protoplasm that moves by pseudopodia. One nucleus is commonly present and a single contractile vacuole. The experiments of DEJDAR can be summarized as follows:
   a. The amoebae possess a positive charge compared with water, an observation contrary to the opinion of THORNTON (see p. 53). THORNTON's statement however refers only to very small amoebae. DEJDAR explained the positive charge with the structure of the endoplasma of Pelomyxa, which is composed of thousands of "granula", having a positive charge that dominates the negative charge of the protoplasm.
   b. The potential difference compared with water is abt. + 20 mV.
   c. No potential differences could be measured between the different points on an amoeba.
   d. The potential difference with water disappears after the death of the amoebae.

3. *Electric potentials during seismonastic movements* (see p. 100):

Bünning (Bibl. No. 585) studied the electric phenomena during seismonastic excitation of *Sparmannia* and *Berberis*. The following results were obtained:

a. The seismonastic phenomenon is accompanied by an action current; the excited place becomes electrically negative (abt. 10 - 20 mV).
b. The maximal negative value is obtained with Sparmannia after 10 sec.; with Berberis after 1 sec.
c. The original potential difference is re-established with Sparmannia after thirty seconds with Berberis after 1 minute.

4. *Relation between electric potentials and the shape of fruits:*

We discussed on p. 15 the experiments of Burr and Sinnot (Bibl. No. 588), which indicated a relation between the ratio of potential differences and the ratio of the dimensions (not with the absolute size).

5. *Relation between electric potentials and heredity:*

Burr (Bibl. No. 587) in 1943 studied the electric potentials of the kernels of pure and hybrid strains of sweet corn. More than 2,000 measurements were made of the standing potential differences between opposite ends of the longitudinal axis and the kernels.

It was found that:

a. the potential differences varied between 6.2 and 24 mV;
b. the point attachment of kernel to cob was always positive and the opposite pole negative;
c. difference of one "gen" between parent species and the hybrid could make a difference of 18 mV in the voltage pattern;
d. high potential differences were found in association with a high degree of hybrid vigor in the field.

The experiments were extended in (about) 1946 with dried maize seeds (Bibl. No. 591). Each seed proved to have a measurable electric potential after it had been soaked in water for 18-24 hours. Two potentials were measured: directly after touching with the electrodes and again after 30 - 120 sec. The latter measurement was required as the potential falls off rapidly until it attains a stable point at which it will remain constant for 2 - 5 minutes. The first potential is called "*primary potential*", the second "*equilibrium potential.*"

It was found by Burr and his collaborators that:

a. the primary potentials are highly correlated to seed variability, but with no other measured attribute of plant growth;
b. the equilibrium potentials seem to be correlated to the inherent genetic constitution of a plant, since by using these potentials it is possible to segregate from a given polulation seeds with superior growth characteristics;

c. the potential differences between seeds could be correlated to the growth of progeny one generation removed.

6. *Relation between diurnal variations in growth of trees and electric potentials*:

Using the *dendograph* McDOUGAL (Bibl. No. 593) found that the majority of trees show a diurnal rise and fall in diameter. In general the maximum occurs shortly after sunrise and the minimum just after noon. This variation lasts only a few months and depends on climatic circumstances. Part of the growth results from increase in the bulk of cytoplasm in the cells of cambium, which is related to the water metabolism. BURR (Bibl. No. 590) discovered that trees with diurnal growing variations possess electric correlates. The rise and fall of the electric potentials of the trees depends on the time of the year. For further details see p. 94.

We have now reached the end of Part I on the chapter "The electromagnetic fields in and around living organisms", which we have described as the "*organic field*". This part has necessarity been extensive in order to lay the scientific basis of the following sections. Many of the following discussions, particularly in chapter III, can be very brief as we may now refer to these basic scientfic facts.

PART II: THE GEOPHYSICAL FIELD

We have discussed in previous pages the different external electromagnetic forces which influence the ordinary physiological processes and the processes in the brains of living organisms. Those forces are created partly by artificial fields, caused by the activities of man himself and partly by natural sources. The natural sources are partly situated on earth and partly in the universe surrounding the earth. A brief summary of the latter phenomena is given on p. 93-96 and will also be discussed in Part III of this chapter.

The disturbing forces on earth, the *geological field*, can be sub-divided into two main fields: the *geophysical field sensu stricto* and the *climatological* or *meteorological field* (see p. 5). The former applies only to the physical forces in or just above the upper part of the earth crust, the latter to the physical fields in the atmosphere above the earth crust. The geophysical field, which is discussed in this second part of chapter I, consists of a great number of different units that can be summarized as follows:

1. *The gravitational field* of the earth: created by the gravitational forces on earth; their influence is briefly discussed on p. 93 (general influence of cosmic forces on colloidal substances),on p. 94 (capillarity experiments of Kolisko), on p. 99 (geotropism) and on p. 94 (influence of tidal movements).
2. *The magnetic field* of the earth: as a whole and of the crust in particular.
3. *The electric field* of the earth crust.
4. *The radioactive field* of the earth crust.
5. *The seismic field* of the earth: result of earthquakes in the earth crust, either due to natural stresses in the crust or to artificial seismic forces. Natural stresses are created mainly by mountain-building movements of parts of the crust (so-called *tectonic forces*), but are also due to volcanic activity and sudden collapse of subterranean caves or sudden downsliding of large masses of loose sedimentary material, etc., the tensions being released by different geological forces such as: large-scale displacements of masses, either in the atmosphere (heavy fall of snow, rain), on the lithosphere (volcanic eruptions) or at sea (stormy weather); beating of waves; tidal movements; tectonic movements; polar fluctuations; sudden changes in atmospheric pressure, etc.
   Artificial earthquakes originate as a result of explosions in the earth crust.
6. *Geothermal field*: Result of the high temperature of the centre of the earth and showing up as *geothermal gradient* in the crust (increase in temperature of abt. 1°C per 33 m) and *volcanic activity*.
7. *Geo-chemical field*: shows up in two important ways:
   a. migration of generally organic gases through the soil and gas-emanation from the earth crust;
   b. volcanic activity and its accompanying physico-chemical processes.

Each of these physical fields has been applied in geological exploration work, the methods used being compiled into a subscience of geology, called *practical geophysics*. The physical methods used in practical geophysics can be divided as follows (see also Bibl. No. 604a — 612):

1. *Gravitational methods*: studying variations of the gravitational field of the earth; the variation was discovered in 1672 by JEAN RICHER, who noted that a clock, the pendulum of which was calibrated to beat seconds in Paris, lost about $2\frac{1}{2}$ minutes a day in Cayenne.

The first practical *gravity meter* was invented in 1833 by Sir JOHN HERSCHEL, after the discovery of the *reversible pendulum* (by H. KATER in 1818) used for measurements of *absolute gravity* and the *invariable pendulum* used for *relative gravity* determinations (the most widely employed one was invented by VON STERNECK). The main development, however, started in the U.S.A between 1928 and 1930. The present gravity meters have an accuracy of up to 0.1 millidyne per gram, which corresponds to an accuracy of one ten millionth of the total value of gravity = abt. 0.1 milligal.

Unit of acceleration due to gravity is called a "*gal*" = acceleration of 1 cm sec/sec; acceleration of the earth = 980 gals; 1 milligal = 10^{-3} gal; 1 dyne = force giving an acceleration of one gal to a mass of 1 gram.

R. VON EÖTVÖS developed the *torsion balance of Coulomb* (used for studies of electric attraction) into a double beam *gravity torsion balance*, which is extremely sensitive to variations in the rate of change of gravity in a horizontal plane and to the curvature values. The EÖTVÖS balance was modified later by SCHWEYDAR, who used a "Z-beam" (unit of gravity gradient is called the EÖTVÖS"; $1E = 1 \cdot 10^{-9}$ dynes/gram/ horizontal centimeter).

2. *Magnetic methods*: measuring variations of the different components of the magnetic field of the earth. The magnetic method is the oldest geophysical method and dates back to at least 2637 B.C., after the discovery by the Chinese of the orientation property of magnetized iron, or "*lodestone*." Exploration methods, however, started only about 1640 A.D., when a compass was used in the search for iron ores in Sweden. In 1843 VON WREDE pointed out that local variations in the magnetic field might be indicative of buried magnetic bodies. The first practical geomagnetic investigations started after the construction of the SCHMIDT *field magnetometer* in 1915. The sensitivity of present-day magnetometers is abt. 2 gamma (see p. 210), and enables gradient measurements of 0.2 gamma/cm.

3. *Electric methods*: measuring either the natural potential field of the earth crust or artificial fields created in the earth crust by electric or electro-magnetic fields; potential methods or measurements of conductivity and its reciprocal value (resistivity), etc., are used.

First electric studies of rocks were made in 1720 by GRAY and WHEELER, who tabulated their electric conductivities.

WATSON discovered in 1746 that the earth crust is a conductor and

that a current passed between electrodes embedded in the ground at a distance of 10,600 feet acted differently than when wire was used to complete the circuit.

In 1815 ROBERT FOX discovered the spontaneous polarization of ore bodies. The first commercial use of this effect was introduced by C. SCHLUMBERGER in 1913.

F. H. BROWN (about 1900) discovered the method of resistance measurements in the soil.

4. *Radioactive methods*: measuring variations in the rate of ionization of the air in the soil, either through direct measurement of radioactive radiation or by determining the amount of radioactive emanation in the air. These methods were developed in this century after the discovery of radioactive elements in 1896 and the radioactive studies of rocks by A. J. STRUTT (1905) and J. JOLLY (1909). Practical application was mainly developed by R. AMBRONN and H. HIRSCHI.

5. *Seismic methods*: based on measurement of differences in transmission speed of seismic waves, created artificially by dynamite explosions in shallow drill holes.

The first studies of natural seismic waves in the earth crust were made in 1761 by J. MICHELL. In about 1860 R. MALLET produced artificial earthquakes by exploding gunpowder and studied the seismic waves with a crude seismometer. The first large-scale application of this method was started about 1905 by L. P. GARRETT, and was perfected only about 1923. During the first world war MINTROP and WIECHERT developed a new mechanical seismograph which is still used in seismic *refraction methods*. R. FESSENDEN discovered in 1914 the *reflection method*, which was perfected by KARCHER, ECKHARDT, and McCOLLUM in about 1927. At present it is one of the most successful geophysical methods that enables prospecting to depths exceeding even 25,000 ft.

6. *Geothermal methods* measure variations in temperature gradients as a function of structural changes in the upper part of the crust. The methods were applied, particularly by E. DE GOLYER (1918), M. W. STRONG (1934), and C. E. VAN ORSTRAND (1935), when prospecting for oil.

7. *Geochemical methods* are based either on *gasanalyses* of macroscopic gas and oil seapages or of soil gas from shallow bore holes (methods of G. LAUBMEYER, 1933 and V. A. SOKOLOV, 1932) or on *soil analysis* of occluded volatile, solid or liquid hydrocarbons. The latter method was mainly developed in the U.S.A. in 1935.

JAKOSKY (Bibl. No. 608, p. 34) has given a summary of the approximate cost per month (in dollars) of geophysical prospecting with different methods:

magnetic method: 500-750
gravitational method:
    gravimeter: 3,000-5,000
    torsion balance: 3,500-4,500
electric method: 3,000-5,000

geochemical method: 3,000-6,000
seismic method:
 reflection: 6,000-11,000
 refraction: 6,000-15,000

It is evident from this brief summary of the different geophysical fields and the methods of practical geophysics, that only four geophysical fields are of direct importance for the study of divining phenomena: the *magnetic*, the *electric*, the *radioactive*, and the *geochemical*. Of these four the first two are the most important and will be discussed more extensively.

We have mentioned the other geophysical methods and their historic development for the following reasons. We discuss in chapter III the publications of different dowsers who recommended the use of certain instruments to replace the divining rod. The great attraction of these divining methods to a great number of people is not only due to the unconscious desire to accept blindly any occult method, but also to the high prospecting costs of the different scientific geophysical methods (see above).

The short summary given above is sufficient to prove the uselessness of occult methods. Up till now the latter, without exception, have been poor imitations of existing geophysical methods and developed mostly by physically and geologically untrained persons, whereas hundreds of first-class physicists and geologists have developed the modern geophysical methods and have tested them carefully. It is of primary importance for every scientific dowser to realize this fact. As long as the human body is used as a geophysical instrument we are dealing with a new type of geophysical prospecting, but as soon as the body is excluded the instruments are bound to be useless, unless an instrument can be constructed which can imitate the complicated physiological processes discussed already in part I and which will be dealt with also in chapter III. However, it seems that science must go a long way before we can develop such an instrument.

1. Magnetic field of the earth

Two problems are of particular importance for the study of divining phenomena and of dowsing in particular: the causes of variations of the normal magnetic field of the earth and the different types of variations and the instruments used for the measurement of these variations. Before we deal with the two main problems a few general remarks should be made on the origin of the magnetic field of the earth and the main elements and constants of the magnetic field.

Origin of the magnetic field of the earth:

As a first approximation, the magnetic field of the earth may be represented as that due to a short magnet placed at its centre, the direction of

which is the line joining the magnetic poles (see fig. 38). However, the study of a map showing lines of equal declination (see further) shows immediately that such a simple representation is not in accordance with observed facts (see also fig. 41).

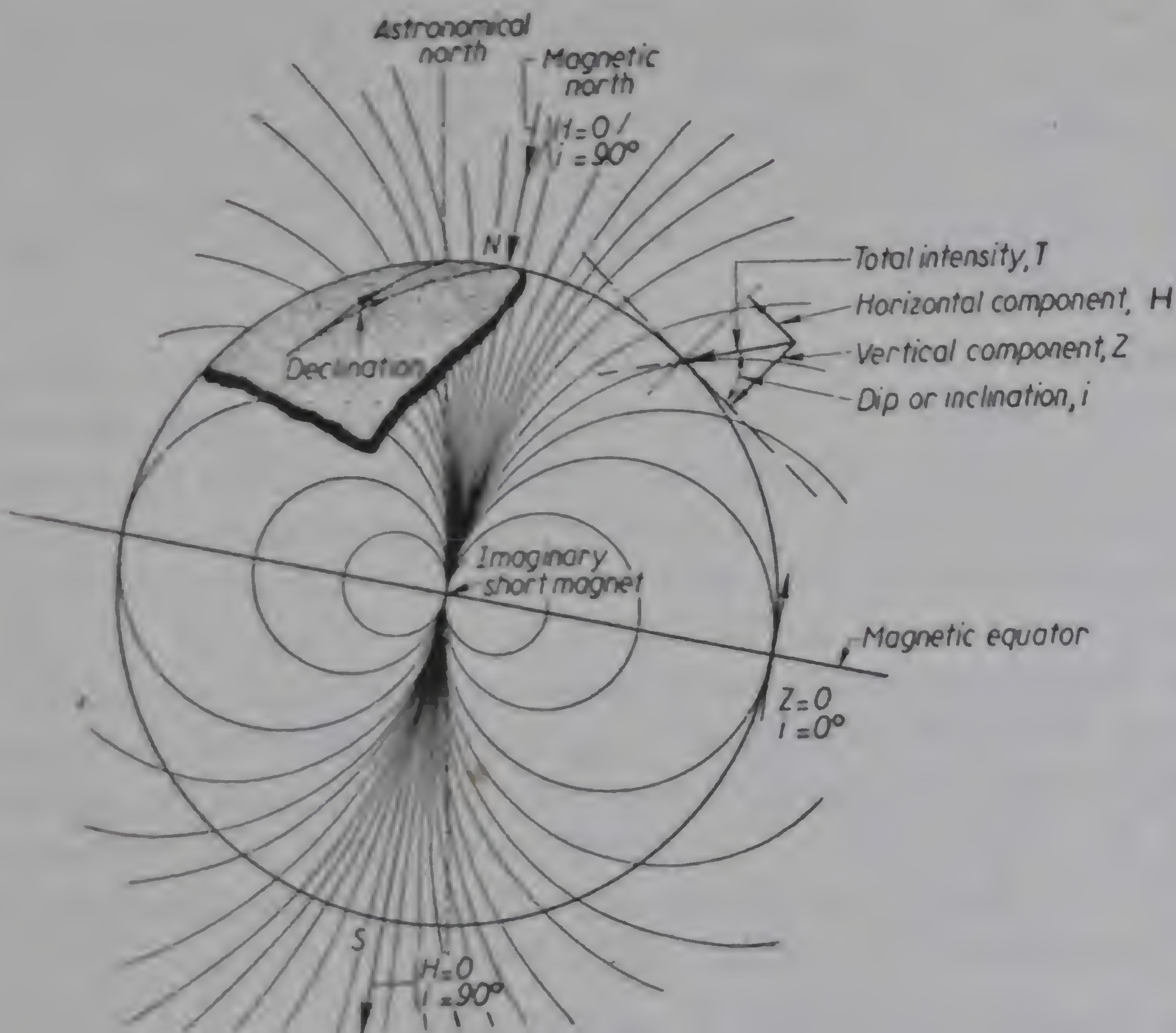


Fig. 38: (Bibl. No. 608, p. 54) Schematic diagram illustrating magnetic field produced by an imaginary bar magnet located at the earth's centre.

Gilbert constructed a model of magnetite and showed that a small suspended needle in the neighbourhood of it dips as a needle does in the earth's field. He made the mistake, however, of assuming that the magnetic poles were at the end of the axis of rotation of the earth.

Gauss (("Allgemeine Theorie des Erdmagnetismus", 1839) could prove mathematically that the magnetic field is not due to an electric current flowing through a closed path upon the earth's surface; he also calculated the values of total intensity and dip all over the earth. He found that the north magnetic pole was in latitude 73°35′ N, longitude 95°39′ W, and the south magnetic pole in latitude 72°35′ S. longitude 152°30′ E. Later determinations in 1906 and 1909 gave the following positions:
North pole 70°30′ N, 97°40′ W.;
South pole: 72°25′ S, 155°16′ E.

There have been several hypotheses put forward in this century to explain the magnetic field of the earth. The relatively small distance between the magnetic and the rotational axis of the earth suggests a relation between rotation of the earth and the magnetic field. Several theories have been developed which are based on this assumption.

1. *Rotation of the electric charges of the surface of the earth and of the atmosphere due to the rotation of the earth* (*theory of Swann*, a.o.): calculations have shown, however, that these electric fields should be 10^{8} times stronger than those observed in order to explain the magnetic field of the earth.

2. *Separation of opposite charges* (*theory of* SUTHERLAND, a.o.): SUTHERLAND assumed that the total positive and negative electricity on earth is situated on two spheres with a difference in radius of $2 \cdot 10^{-8}$ cm. Due to the rotation and separation of both spheres the magnetic field of the earth would appear to be created, but later mathematical studies deny this possibility.

3. *Orientation of the molecular magnets on earth*: this hypothesis assumed that rotation of the earth has a directing effect on the electron-orbits of the different bodies on earth. BARNETT could show experimentally that on a globe with the rotational speed of the earth this rotational speed would create a field 10^{10} smaller than the actual observed fields.

Another hypothesis, which could be used alone or in combination with the above-mentioned hypotheses, assumes a *heavy magnetic nickle-iron core of the earth.* The specific gravity of this core, being more than 10.0 (which can be deduced from the average specific gravity of the rocks of the earth crust, 2.7, and the density of the earth as a whole, 5.52, which is based on astronomic data) and the discovery of heavy nickle-iron meteorites support this theory.

The main elements of the earth-magnetic field:

At any point of the surface of the earth the magnetic field is defined by its direction and intensity. The *total intensity* (*T*) in a point on the northern hemisphere (see fig. 38) causes a freely-suspended magnetic needle to dip with the N. pole downwards under a certain angle (i), the *inclination.* The total intensity (T) is the resultant of two components, the *horizontal intensity* (H) and the *vertical intensity* (Z). The horizontal component is often resolved again into a north-south component (x) and an east-west component (y). The angle beween horizontal intensity and astronomical north is called *declination.*

The magnetic intensity at a point was measured originally in *Gauss units*, i.e., the *field strength* at that point, created by a magnetic field, which exerts a force of 1 dyne on a unit pole. For practical purposes not the Gauss but the *gamma* unit is used, i.e., 10^{-5} Gauss.

The total intensity of the earth magnetic field in the U.S.A. is of the order of 0.6 Gauss = 60,000 gammas. The horizontal intensity in Holland (about 1920) was 0.184 Gauss = 18,400 gammas.

Lines connecting points of equal declination on earth are called *isogonal lines* or *isogones;* lines of equal inclination are called *isoclinal lines* or *isoclines;* lines of equal intensity are called *isodynamic lines.* The isocline of 0° is called *acline* or magnetic equator.

Magnetic properties of materials:

We explained on p. 74 (fig. no. 6) the differences between *ferro-magnetic, para-magnetic, diamagnetic* and *non-magnetic material* and the deeper physical causes of those differences (see p. 75). We have discussed two important magnetic constants, the *permeability* and *susceptibility* (see p. 74) and we have compiled in a table the different values of those constants both for elements and minerals (see p. 75 and 76). On p. 75 we pointed out that in most heterogeneous bodies the outer magnetic conditions are determined by the relative magnetic susceptibilities of the different components, the percentage of each mineral in the rocks and the distribution in space of those rocks. We mentioned also the fact that traces of ferro-magnetic substances (minerals ilmenite, pyrrhotite and magnetite) are able to create para-magnetic effects; magnetic disturbances in the earth field are caused, not only by such local differences in para-magnetism (see fig. 46), but also by the presence of large diamagnetic bodies in para-magnetic surroundings which create considerable disturbances in the normal distribution of the magnetic lines of force (see fig. 6).

We discussed also the phenomena of permanent magnetization of metal objects in the earth field (p. 84), of rock cliffs and lava flows (p. 85); the importance of local magnetization, caused by lightning, was briefly mentioned on p. 85.

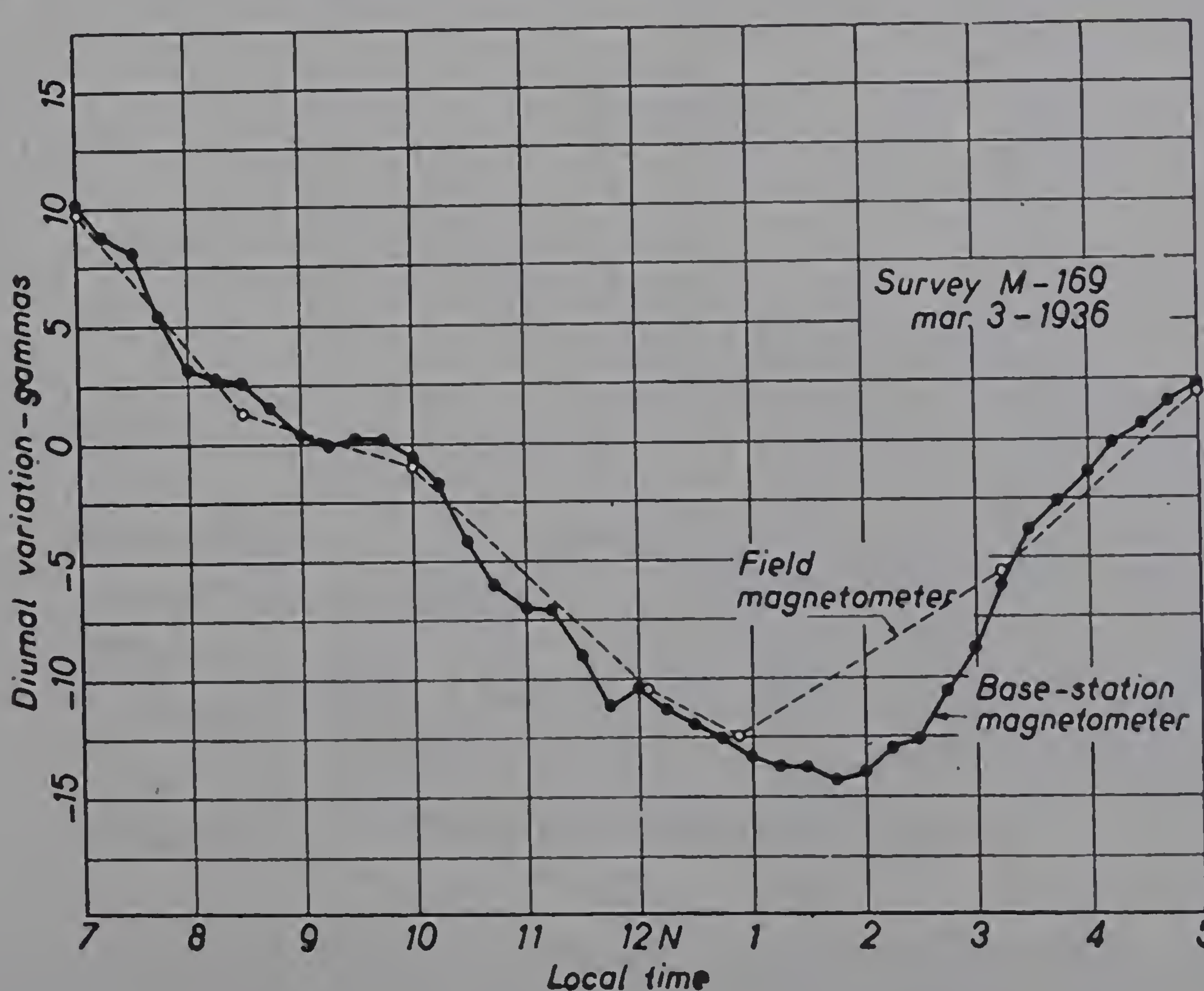


Fig. 39: (Bibl. No. 608, p. 106) Graph showing diurnal variation as given by field and base station magnetometers.

A. Causes of variations of the normal magnetic field of the earth

The magnetic elements on earth vary continuously at all points, both as a function of time and of space. These changes may be resolved in a number of rather permanent and non-permanent changes, the latter being divided again into periodic and non-periodic, mostly sudden,

irregular changes. The permanent changes are due to geological causes, the non-permanent ones are the result of cosmic and meteorological effects. We shall discuss first the latter phenomena.

1. A. 1. Cosmic causes of variations in magnetic elements

a. *Daily variation:* a diurnal variation occurs of the earth magnetic

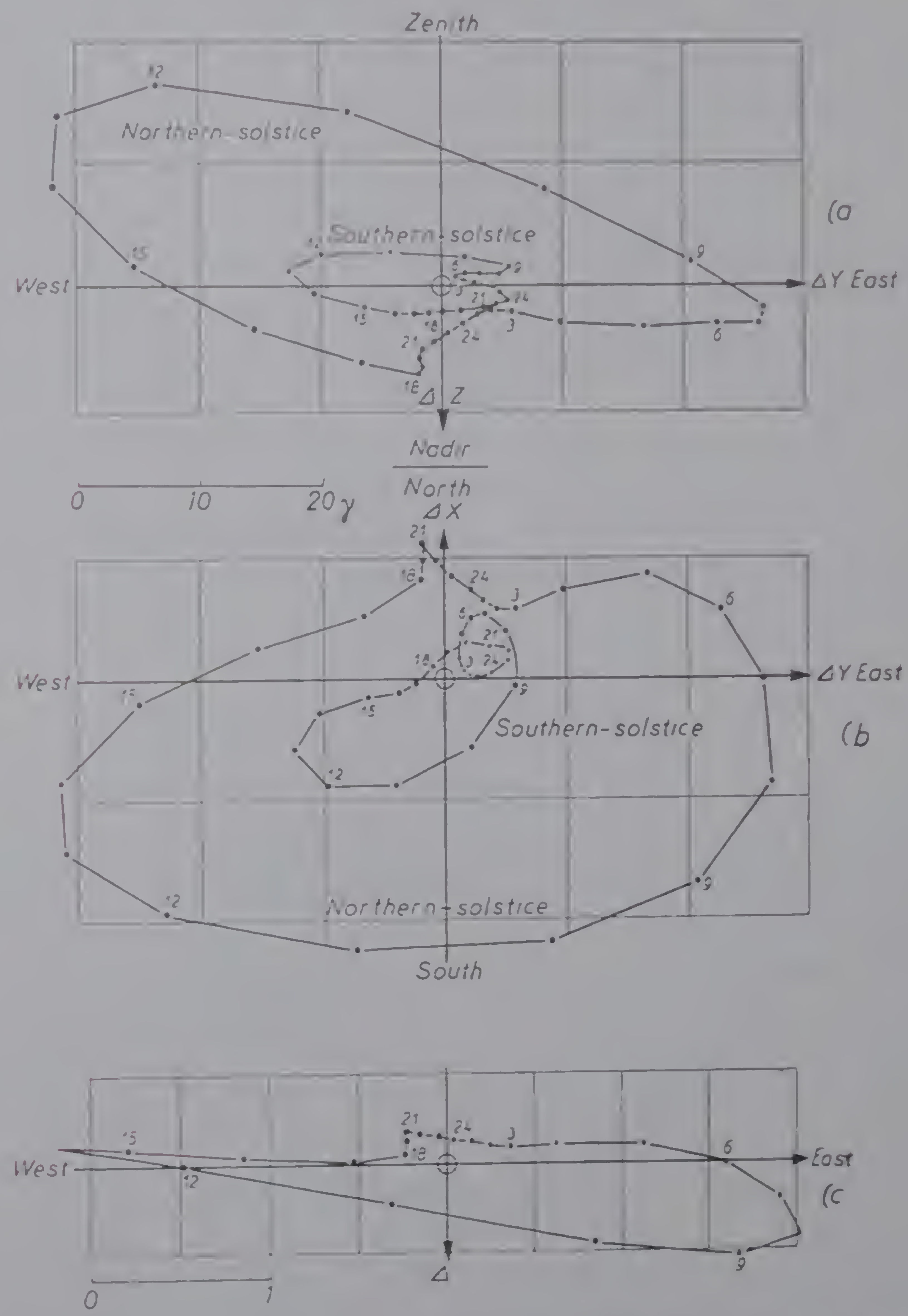


Fig. 40: (Bibl. No. 606, p. 413) Vector diagram of the average daily variations of the magnetic field of the earth at Potsdam in the period 1911-1920. The curves represent the movements of the terminal point of the field strength vector, length of total vector taken at 50 m.
A) Projection of vector movements on an E.W. vertical plane ($\triangle Y$, $\triangle Z$).
B) Projection on a horizontal plane ($\triangle x$, $\triangle y$).
C) Projection of conical movements of an inclined, freely suspended magnet. The cross section of the cone, being but a few arc-minutes, is only observable if the axis of the cone is 50 m long.
Northern solstice (May-August); southern solstice (November-February).

field, both in intensity and direction; this is represented in fig. 39. It causes a change in declination at a fixed point of abt. 10′. The daily variation is not constant, the change in declination in Holland being smallest in the morning and greatest at 2 o'clock in the afternoon; it is less in winter than in summer. The amplitude of the horizontal intensity varies up to 50 gamma. It has been found that if the daily variation is represented in a vector diagram (see fig. 40), according to the method of v. Bezold, in all points on the earth having the same latitude, the vector diagram has the same shape.

A. Schuster (1889) investigated the phenomenon of daily variation and concluded that it results from cosmic causes that create variations

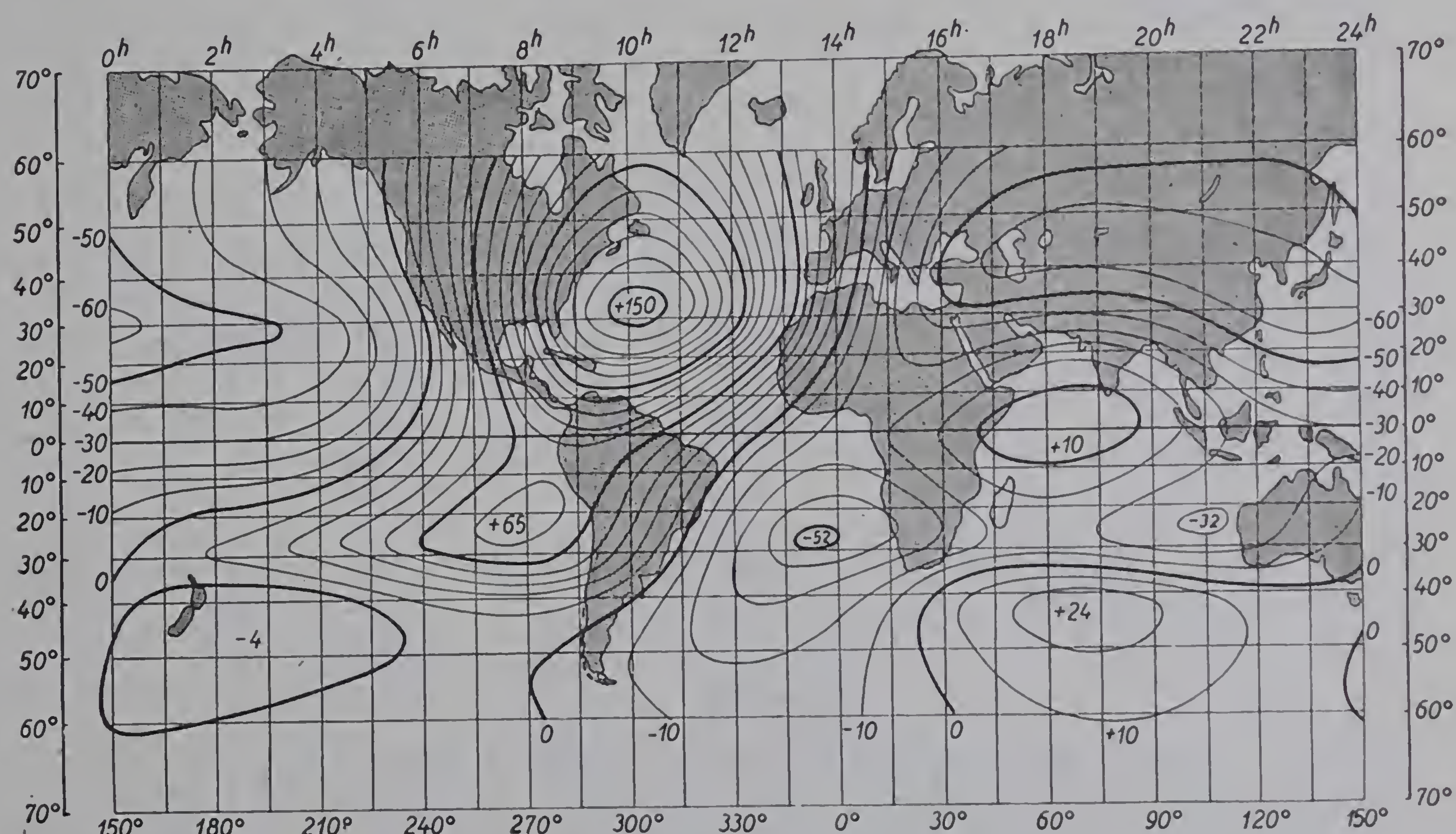


Fig. 41: (Bibl. No. 606, p. 417) Lines of equal atmospheric electric currents in the highly conductive upper parts of the atmosphere, creating the diurnal variation of the magnetic field of the earth (after F. Bidlingmaier). The diagram is taken as an average for the months May-August, during a period of minimum sunspots, at the moment the sun passes the meridian of 30° W. The current-system moves with the sun in a westerly direction. Current between two neighbouring lines in diagram = 10^4 A. Numbers in diagram indicate currents of 10^3 A e.g., 24 indicates a whirl with a total electric current of 24,000 A. Positive sign means a clockwise rotation of the current; this creates a magnetic field according to the corkscrew rule of Maxwell.

in the electric currents of the atmosphere (see fig. 41). The greatest part of this effect is caused by the sun, but a minute part is also due to the moon.

b. *Thirteen-day period:* the daily amplitude increases for 13 days and decreases again during the same period.

c. *Lunar period:* the daily amplitude changes periodically abt. 2 gamma, in a period of 28 days.

d. *yearly variations:* the declination also changes during the year (see

fig. 42). This occurs simultaneously in opposite directions in the northern and southern hemispheres, the amplitude being abt. $2\frac{1}{4}'$ in London. The maximum easterly deviation occurs in August, the westerly in February.

e. *Secular variation:* the declination undergoes also a long-period change

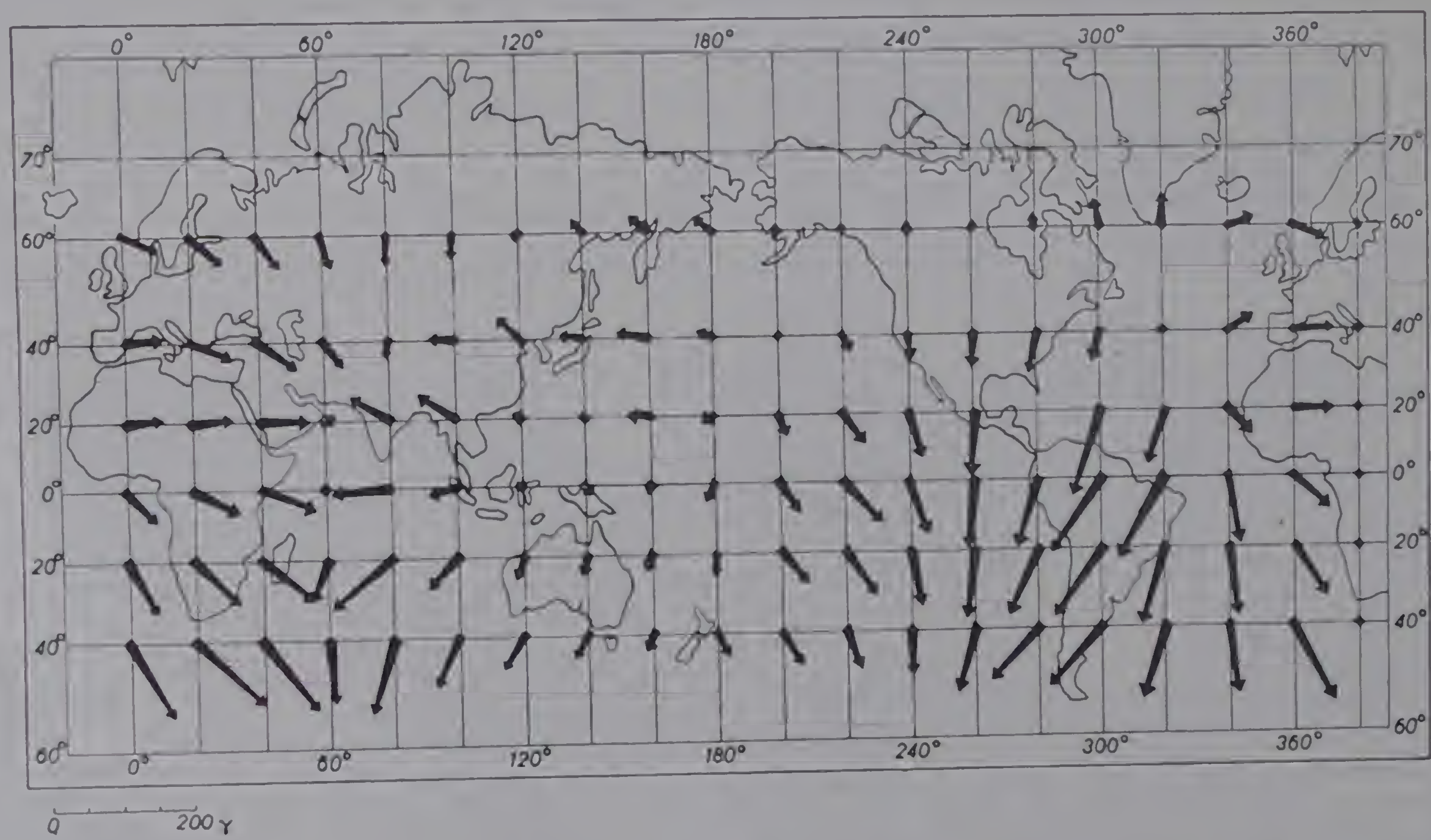


Fig. 42: (Bibl. No. 606, p. 407) Horizontal vectors of the yearly secular variation in the period 1922.

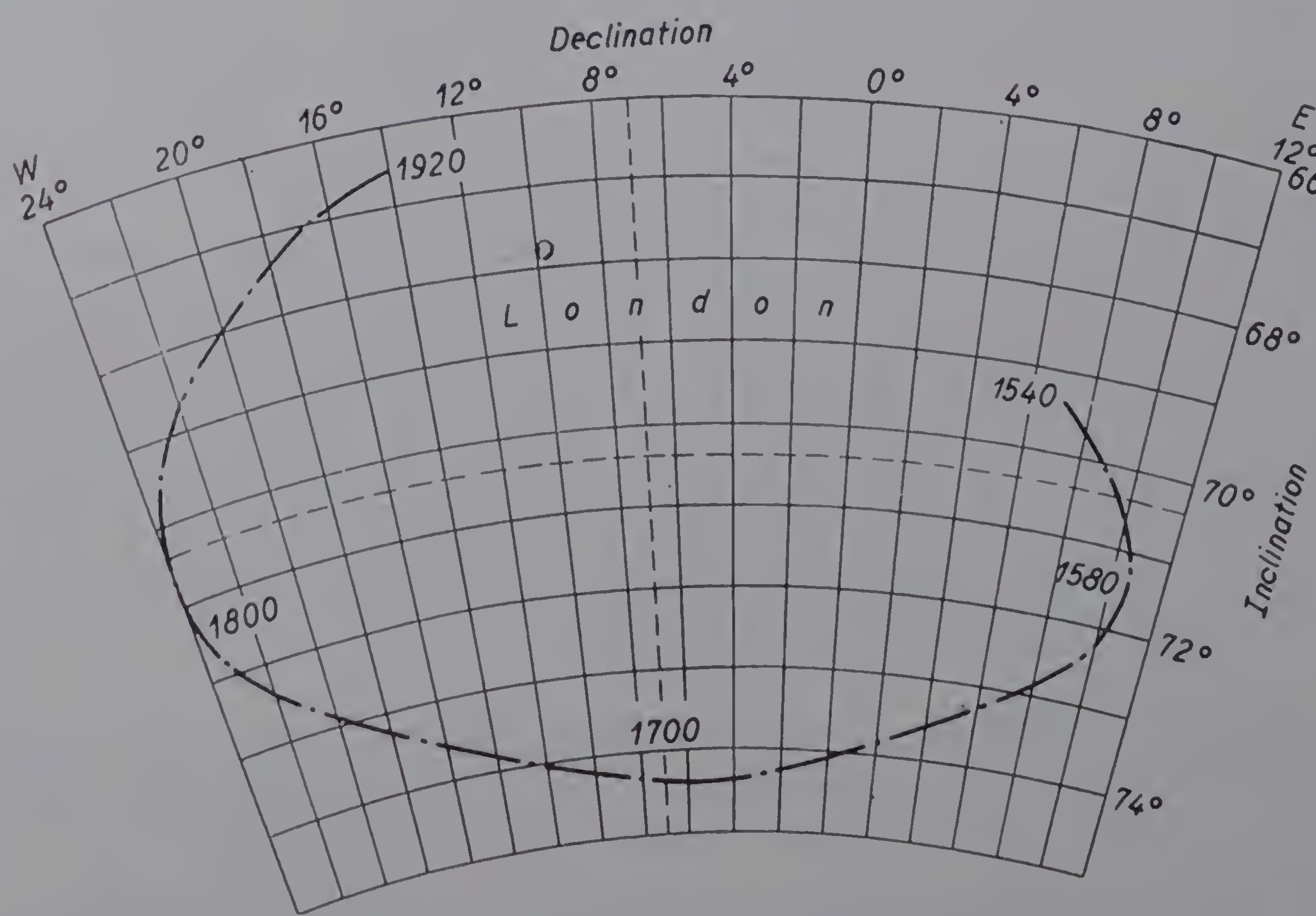


Fig. 43: (Bibl. No. 606, p. 408) Secular variations of an inclined magnet in London during the period 1540-1920 (after L. A. BAUER); the curve represents a cross-section perpendicular to the axis of a cone, described by the needle, taken at a distance of 20 cm from the suspension point of the magnet.

(see fig. 43). The change in declination in London amounted to abt. 11°15′ in 79 years (1580-1659). Lord KELVIN pointed out that the magnetic system slowly rotates from east to west, making one revolution in 960 years. The magnetic north pole describes a small circle of abt. 17° radius.
f. *Magnetic storms:* simultaneous rapid variations in the magnetic elements over the whole earth are called magnetic storms. The disturbances can be considerable and are related to periods of great sun activity (see fig. 44).

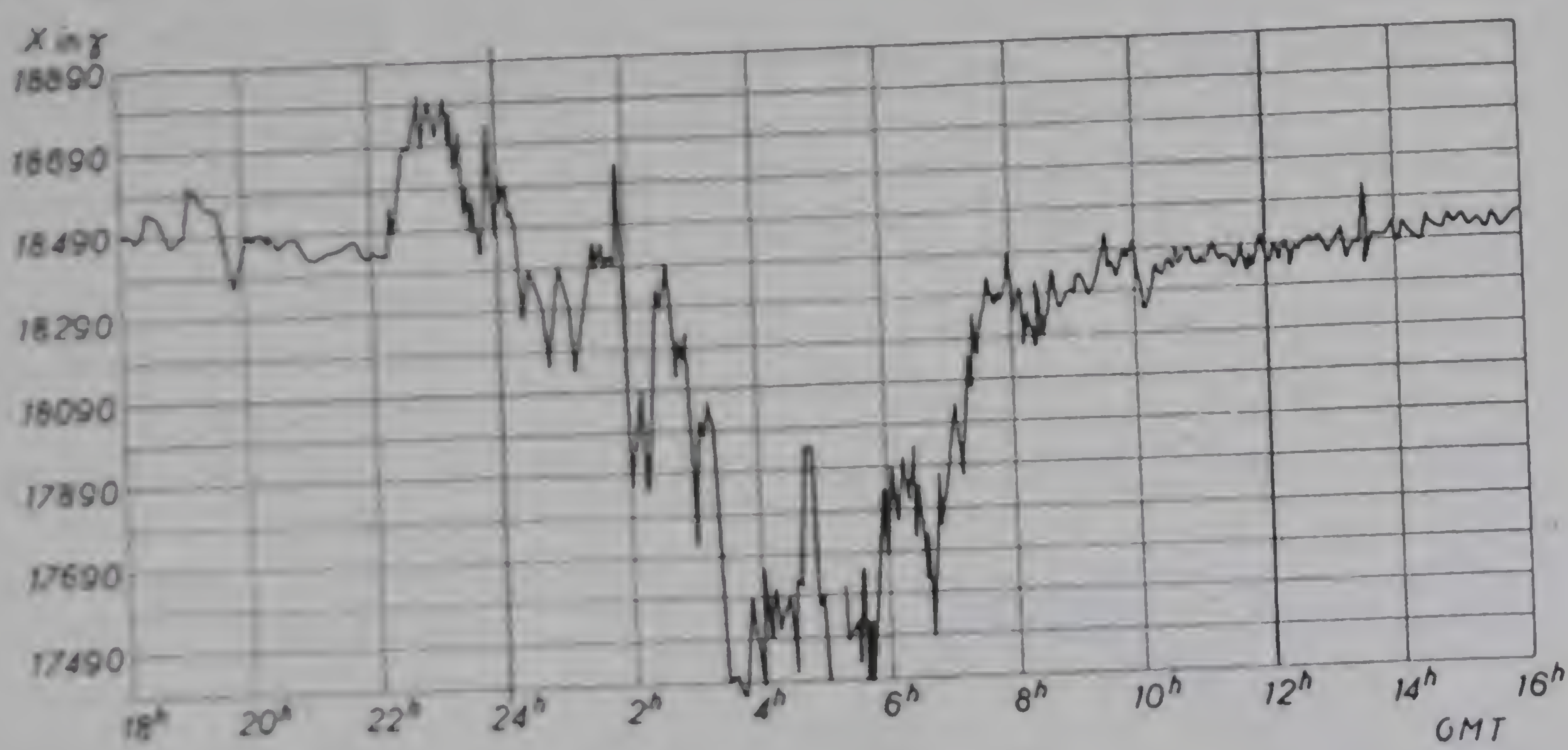


Fig. 44: (Bibl. No. 606, p. 421) Graphic representation of a magnetic storm on 14-15 May 1921, registered at Seddin (Potsdam).

g. *Eleven-year period*: a great parallel occurs between the frequency of sun spots and the magnitude of the daily variations in the magnetic elements (see fig. 45). This is related to a period of 11 years. It is explained with the corpuscular radiation of the sun, which creates electric currents in the ionosphere as a result of increased ionization (see fig. 41 and part III, chapter I).

BAUER noticed, during a total eclipse in 1900, a small wavelike dis-

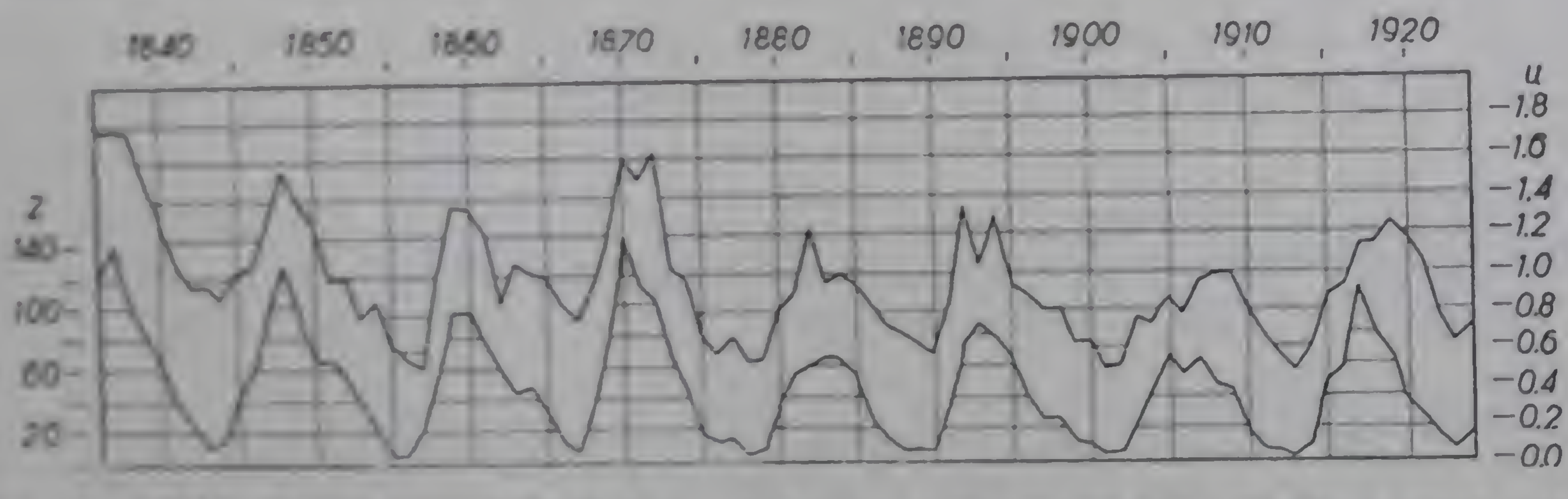


Fig. 45: (Bibl. No. 606, p. 428) Relation between earth magnetic activity (upper curve) and activity of the sun (lower curve) during the period 1836-1924. Earth magnetic activity was determined as the average value of the differences between the daily averages of the horizontal intensity, measured in the magnetic equator in units of 10 γ.

turbance of a suspended needle, at the moment the moon passed over the sun's disc. This change was recorded at all observing stations as the moon's shadow passed over them.

1. A. 2. Geological causes of variations in the earth magnetic field

The earth crust is composed of a magnetically heterogeneous assemblage of rocks of which some exhibit the properties of induced magnets and superimpose their own field on that of the earth. These *superimposed fields* are called *major*, *continental*, *regional*, or *local anomalies*, depending on the scale of the geologic irregularities which produce them.

Continental anomalies have been found to be negative in Europe and positive in N. and S. America.

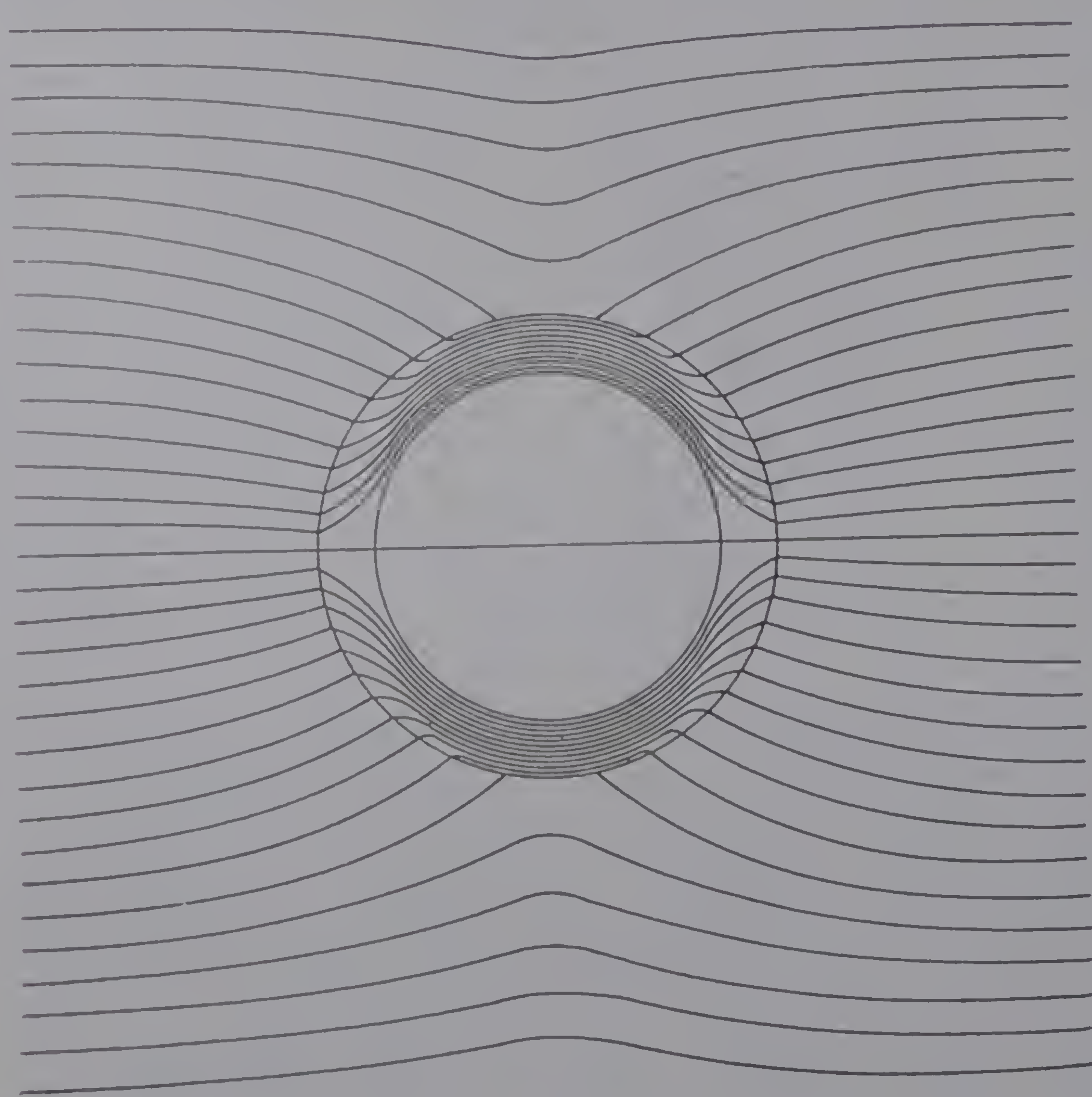


Fig. 46: Disturbance in the lines of force of the magnetic field of the earth created by an iron pipe.

Regional and local anomalies are closely related to the petrographic (rock) and tectonical (mountain-building) structures of areas in which they occur. Figs 46 to 53 show a few of the most important cases of magnetic anomalies which can be observed during geological exploration work.

We discuss in chapter III the ability of certain dowsers to detect variations in magnetic fields of less than 10^{-3} gauss (see p. 312). The values of the regional anomalies shown in figs 46-53 indicate that these anomalies are sufficiently large to be registered by dowsers. A comparison of fig. 47 and fig. 99, which we discuss more in detail on p. 317 indicates the significance of variations in the earth magnetic field for the study of divining phenomena.

B. Methods and instruments for measuring the variations of the magnetic field of the earth

The methods can be divided into two groups: those used for determining the absolute values of the magnetic elements of the earth's

field over extended areas and those for determining the relative values of the magnetic elements over limited areas.

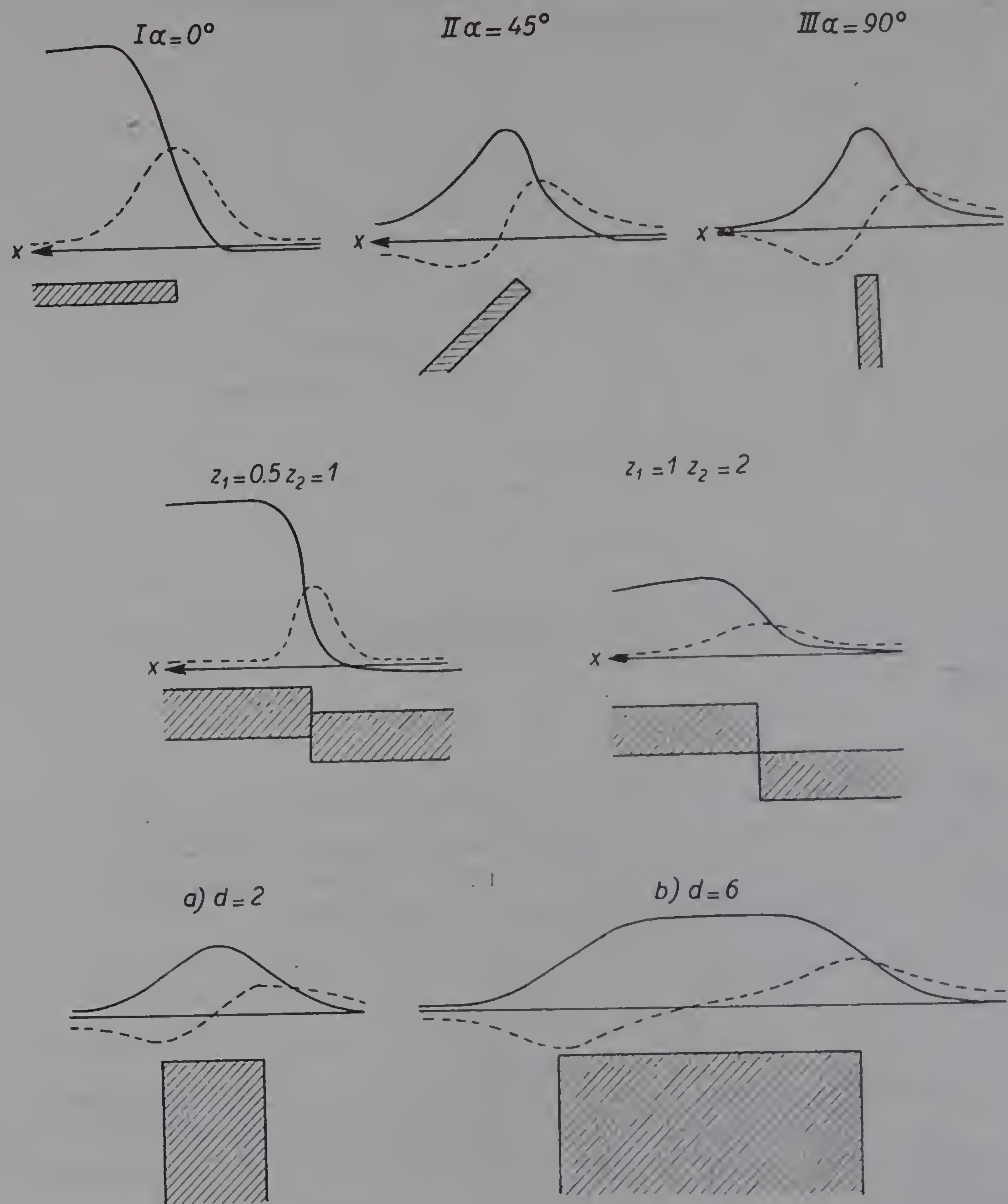


Fig. 47: (Bibl. No. 606, p. 563) Magnetic effect of non-undulated, infinite layers measured in the magnetic meridian.
Dotted lines indicate variations in horizontal intensity; solid lines represent vertical intensity; inclination $63^1/_2°$.

3 upper curves represent the influence of a layer of equal, but not very great, thickness dipping under different angles (α).

2 middle curves represent the influence of a horizontal layer separated into two parts by a fault. Distance of the upper side below the surface of the earth (z) equals half, the same or twice the thickness of the layer.

2 lower curves represent the influence of a vertical layer with thickness d-times the depth below the surface of the earth.

The instruments used vary with the kind of magnetic component for which measurement is required. The different methods can be summarized as follows:

1. B. 1. Methods used for absolute values

a. Measurement of absolute declination: declinator
b. Measurement of inclination:
   dip circle
   earth inductor
   dip needle

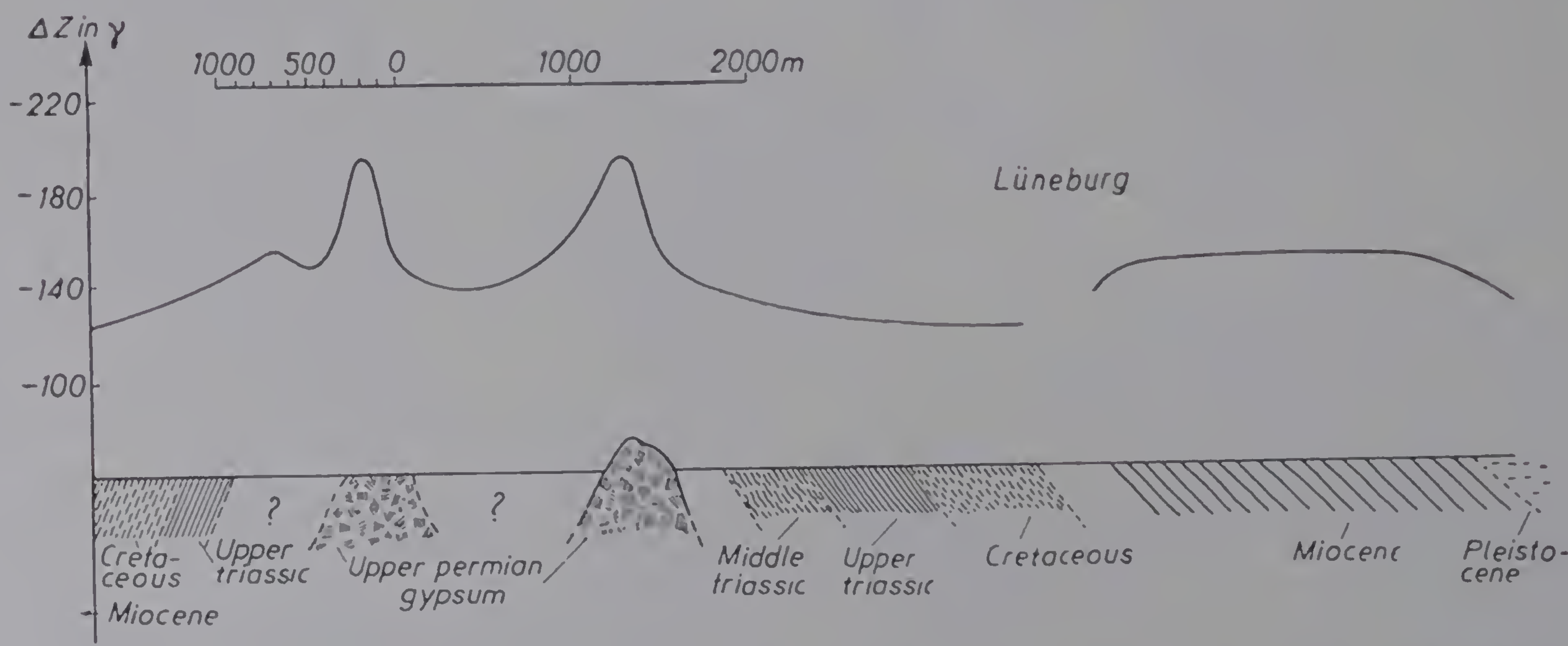


Fig. 48: (Bibl. No. 606, p. 570) Variations of the vertical intensity of the magnetic field of the earth along a section at Lüneburg (Germany) above salt-domes, creating slight negative anomalies resulting from the magnetic permeability being less than the surrounding sediments (after C. HEILAND).

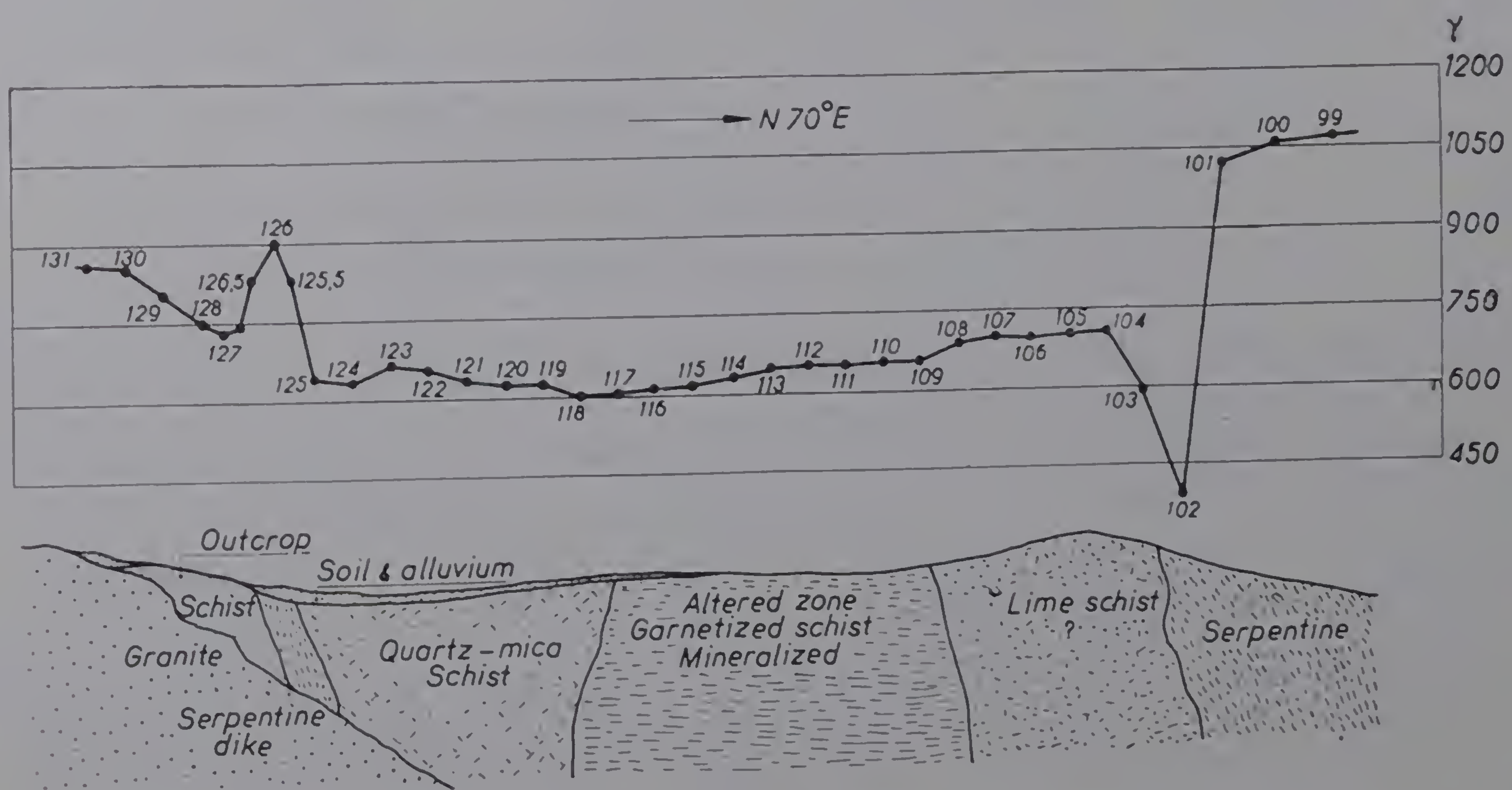


Fig. 49: (Bibl. No. 608, p. 140) Magnetic profile over contacts of lime schist and serpentines in a section N 70° E. High magnetic permeability of serpentine gives rise to the large anomaly at the contact between schist and serpentine at the right end of the profile and a short abrupt anomaly at the left end. Due to relatively small difference in permeability between quartz mica schist and altered garnetized schist there are no appreciable magnetic anomalies at contact. High permeability of granite basement is shown by gradual rise of curve at left end.

c. Measurement of horizontal intensity:
    sine-galvanometer
    Kohlrausch-magnetometer
    electro-magnetic deflection magnetometer
    Thalen-Tiberg-magnetometer
    Wilson-magnetometer
    Dahlblom pocket-magnetometer
    Hotchkiss superdip-magnetometer
    Electro-magnetometer
    Schmidt magnetic field balance (see figs. 54-56)
    airborne-magnetometer

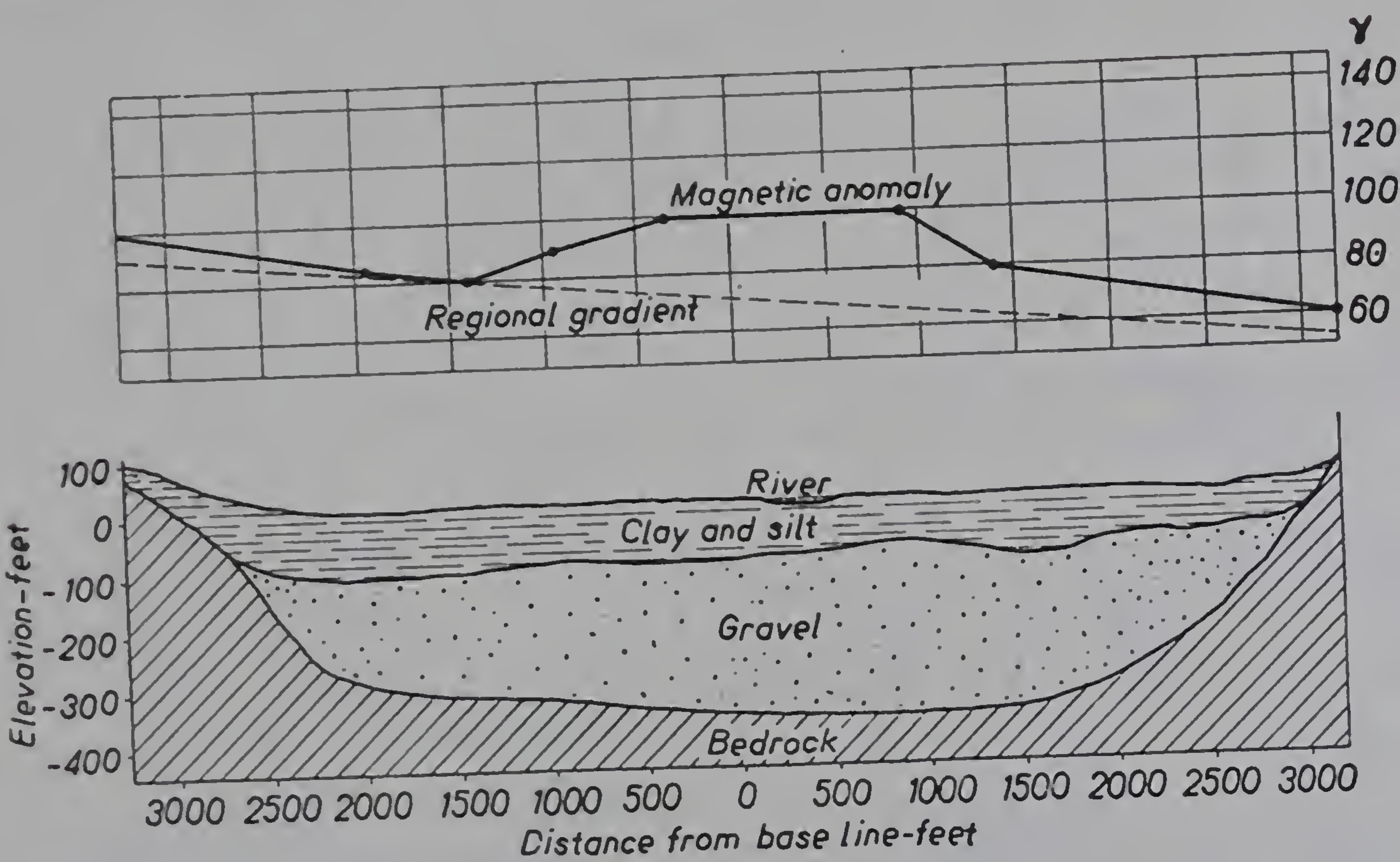


Fig. 50: (Bibl. No. 608, p. 145) Magnetic traverse across a simple placer concentration in the bed of an old stream in Trinity county, California.
Presence of a thick gravel layer might cause a considerable magnetic anomaly.

d. Measurement of vertical intensity:
    induction variometer
    magnetic balance
    see also: Thalen-Tiberg magnetometer
        Schmidt-Askania magnetometer
        electro-magnetometer

e. Measurement of different magnetic components: magnetron

It is not wfthin the scope of this publication to discuss each of these instruments extensively. They are fully described in Bibl. No. 604a-612 and in the references indicated in those publications. A few words may be said on the general principles in order to facilitate the reader in evaluating the instruments proposed by different dowsers.

Sub a. The *declinator* is used to determine the magnetic meridian; it consists of a magnetic needle provided with a mirror and a telescope mounted on a transit base.

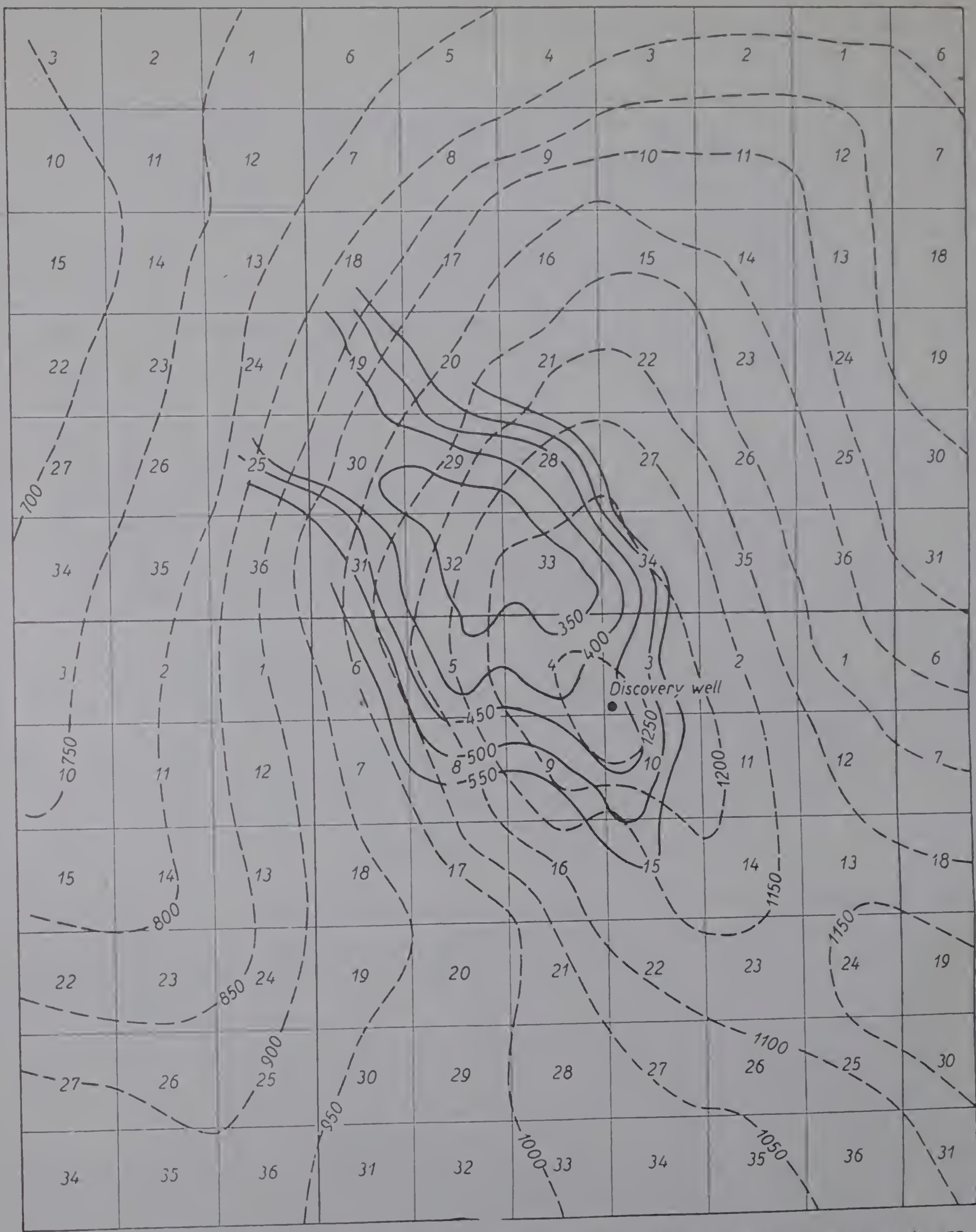


Fig. 51: (Bibl. No. 608, p. 142) Magnetic contours (dotted lines) and structure contours (solid lines) of Hobb's Oil Field, Lea County, New Mexico. Figures on dotted lines indicate magnetic anomaly in γ.

Sub b. *Dip circle* consists of a magnetized needle free to swing in a vertical plane and a circle graduated in degrees.

Earth inductor is based on the principle that when a coil of wire is rotated in a magnetic field, an E.M.F. is induced in the coil, and is dependent upon the number of lines of force cut by the coil. To

determine the inclination it is only necessary to measure the angle of the coil when no current flows during rotation; in that case the coil is parallel to the magnetic field.

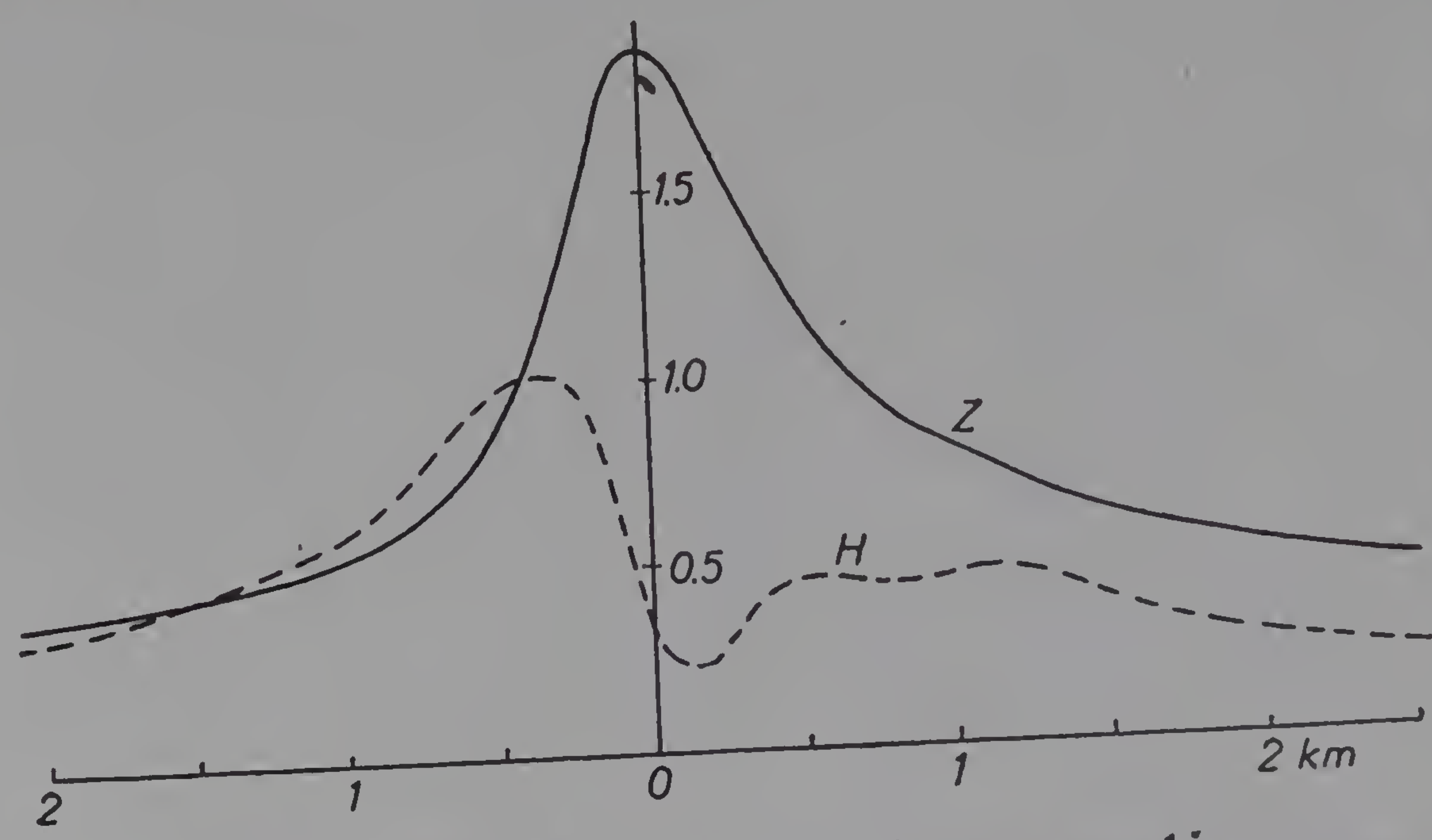


Fig. 52: (Bibl. No. 606, p. 568) Magnetic profile perpendicular to the 200 KM long fault-line at Kursk (Russia). Dotted line = variation of horizontal intensity; solid line = vertical intensity. Rate of anomalies expressed in 1,000 γ.

Dip needles are used in areas with very large magnetic anomalies, e.g., Swedish iron districts. The old dip needles were free to move in a vertical or horizontal plane. Modern needles are only free to rotate in a vertical plane.

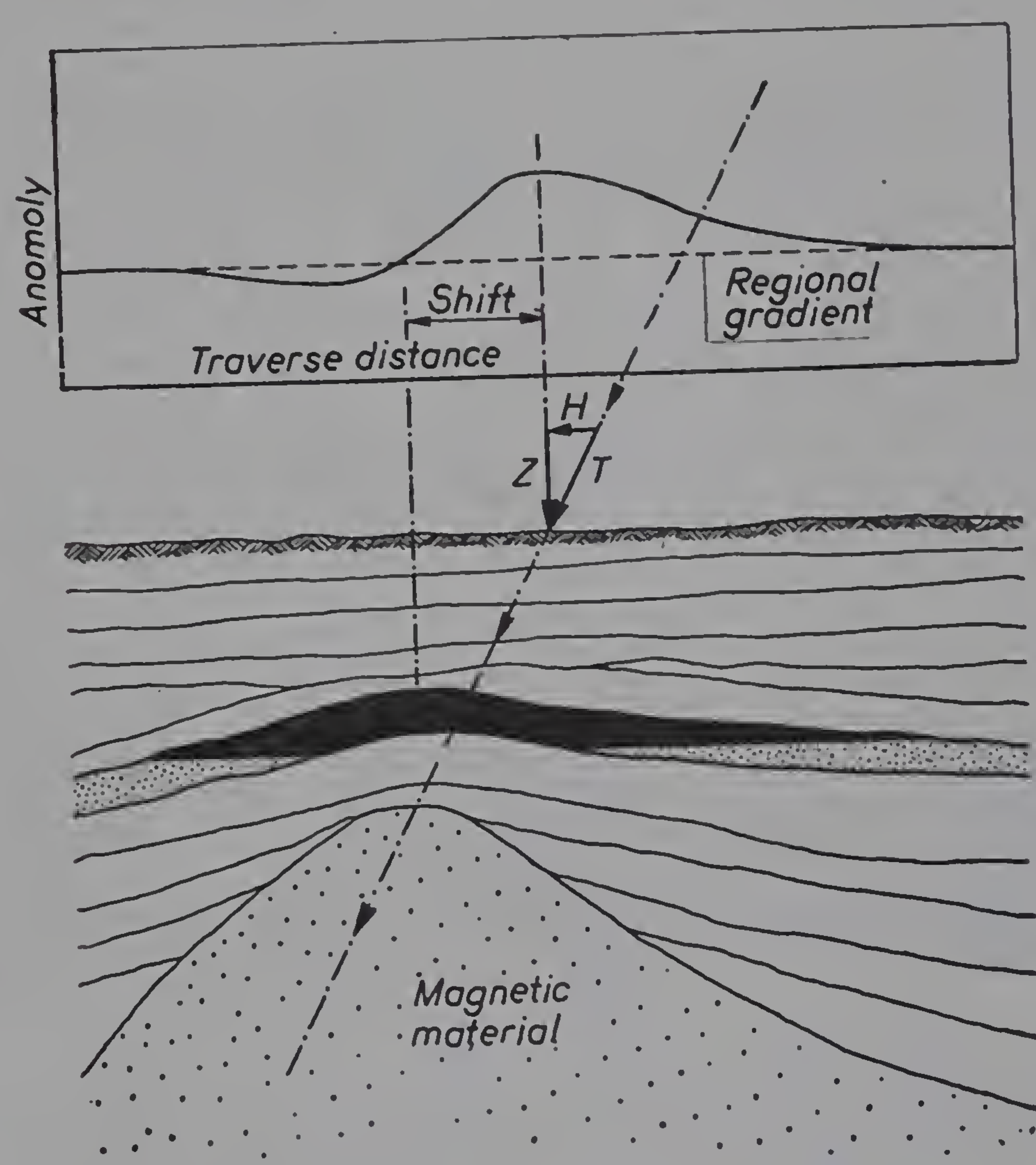


Fig. 53. (Bibl. No. 608, p. 141) Diagram illustrating displacement of the peak of the magnetic anomaly with reference to the crest of the structure below the surface of the earth.

Sub c. Instruments which can determine the absolute value of the horizontal intensity by a combination of two operations (oscillations and deflections) are called *magnetometers* (although instruments using only the deflection method are also often called magnetometers).

The *oscillation method* uses the following principle. If a magnet is free to rotate in a horizontal plane and is displaced out of the magnetic meridian, it starts oscillating because of the horizontal intensity. Determination of the oscillation enables the observer to calculate the quotient of the magnetic moment (M) and the horizontal intensity (H) ($MH = 4 \frac{\pi^2 I}{T^2}$, I = moment of inertia, being either calculated or determined experimentally).

The *deflection method* uses the rate of deflection of a magnet, moving freely in a horizontal plane, the deflection being caused by another magnet brought close to it. "The magnetometer consists essentially of a small magnet suspended by a practically torsionless fibre in a non-magnetic case and two horizontal arms which are attached to the base of the case. One arm carries a cradle which supports the

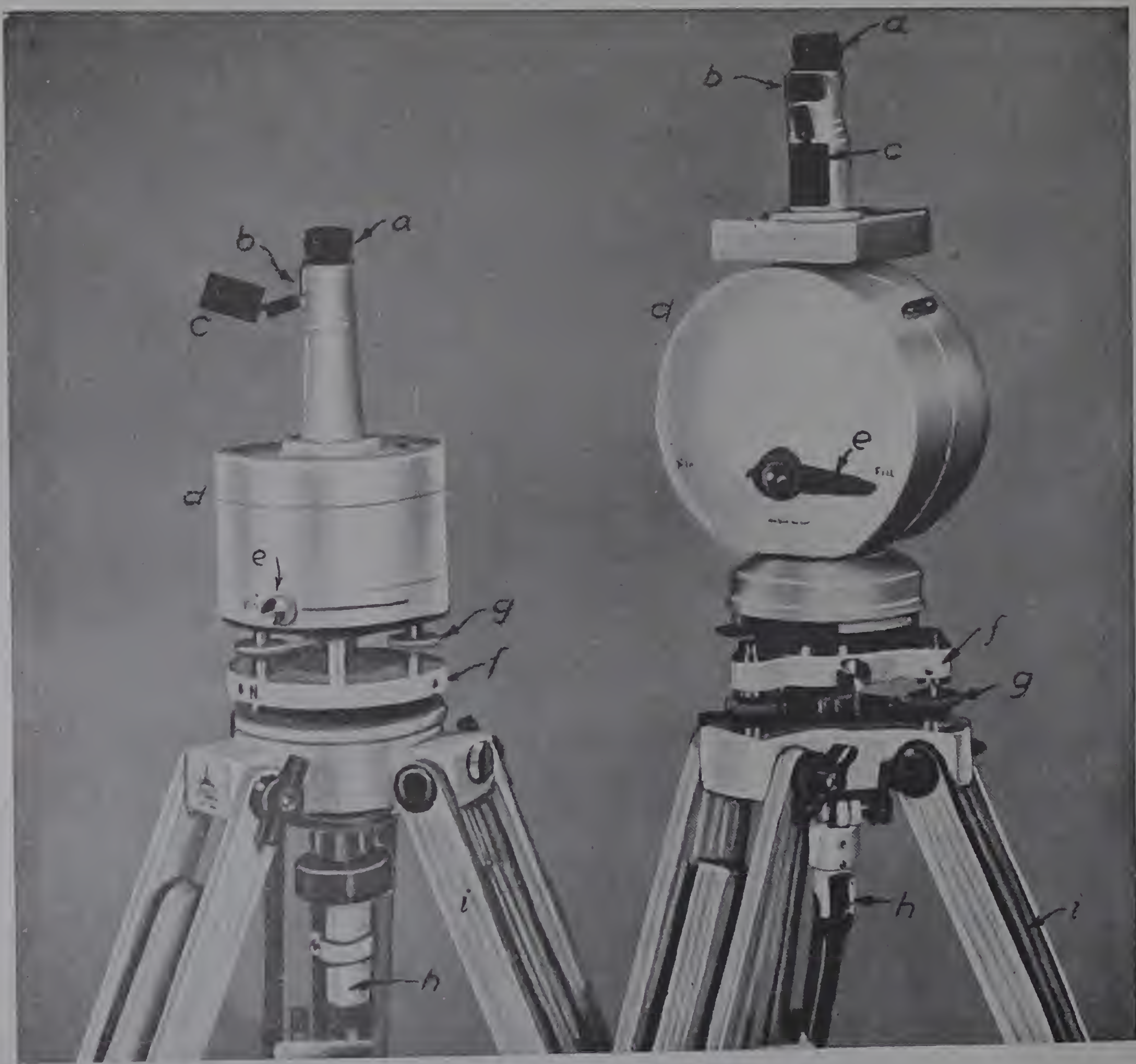


Fig. 54: (Bibl. No. 608, p. 94) A = Standard Askania magnetometer for measuring vertical or horizontal magnetic intensity; B = simplified Askania vertical magnetometer; a = gauss eyepiece; b = light window; c = mirror; d = instrument case; e = clamp lever; f = tripod head; g = levelling screws; h = auxiliary magnet holder; i = tripod legs.

scale, the other carries a cradle which supports the auxiliary magnet during the deflection experiments" (see Bibl. No. 608, p. 69).

Different types of magnetometers have been developed:

The *sine galvanometer* is based on the deflection principle, the deflection being produced by an electric current; the *Kohlrausch magnetometer* uses a magnet for deflection; the *electro-magnetic deflection magnetometer* uses a current in a coil for deflecting the needle; the *Thalen-Tiberg magnetometer* may be used both for horizontal or vertical intensity. It combines a deflection magnetometer and magnetic balance. The *Hotchkiss superdip magnetometer* is a magnetic field balance which combines

in one instrument the function of a dip needle and a magnetometer. The *electro-magnetometer* is a modified earth conductor which can be used for measuring both horizontal and vertical intensity. The *Schmidt-Askania field balance* is a very common type of magnetometer. It consists of two types; one measures the vertical intensity, the other the horizontal intensity (see figs. 54, 55, 56).

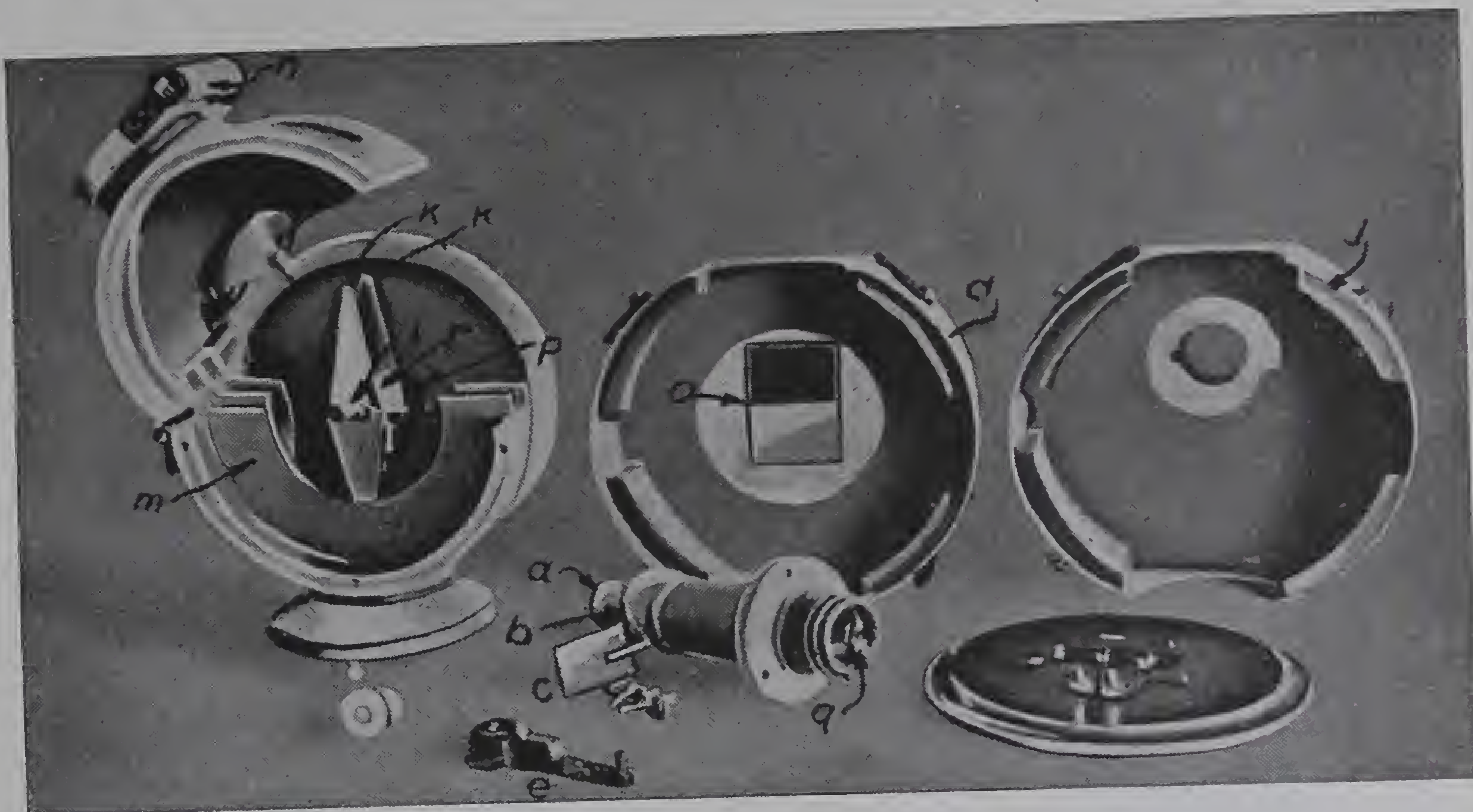


Fig. 55: (Bibl. No. 608, p. 93) Interior view of Askania horizontal component field balance. a = gauss eyepiece; b = light window; c = mirror; d = instrument case; e = clamp lever; j = cork thermal insulation; k and k′ = magnetic system; l = quartz knife-edge; m = copper damping plates; n = level bubbles; o = door in case with mirror attached for reading thermometers; p = counter-balances; q = objective lens; r = mirror.

Continuously recording magnetometers were developed recently, which enable magnetic surveying from the air. This *airborne magnetometer* (more popularly known as DOODLEBUG) was developed by the Gulf Oil Corporation just before the war and was perfected by the American Navy, Columbia University and the Bell Telephone laboratories for detecting U-boats. The instrument is towed by an aeroplane at the end of a long cable and enables a large area to be surveyed in a few hours The great advantage is that the magnetic chart varies for different heights. The higher the survey is made, the less will be the influence of the local disturbances near the surface of the earth.

Sub d. *Induction variometers* consist of four staves, mounted with their long axes vertical, the induced magnetization in the direction of the long axes depending only on the vertical component of the earth's field. A special apparatus enables the observer to measure the changes in induction.

Magnetic balances consist of an apparatus which neutralizes the vertical

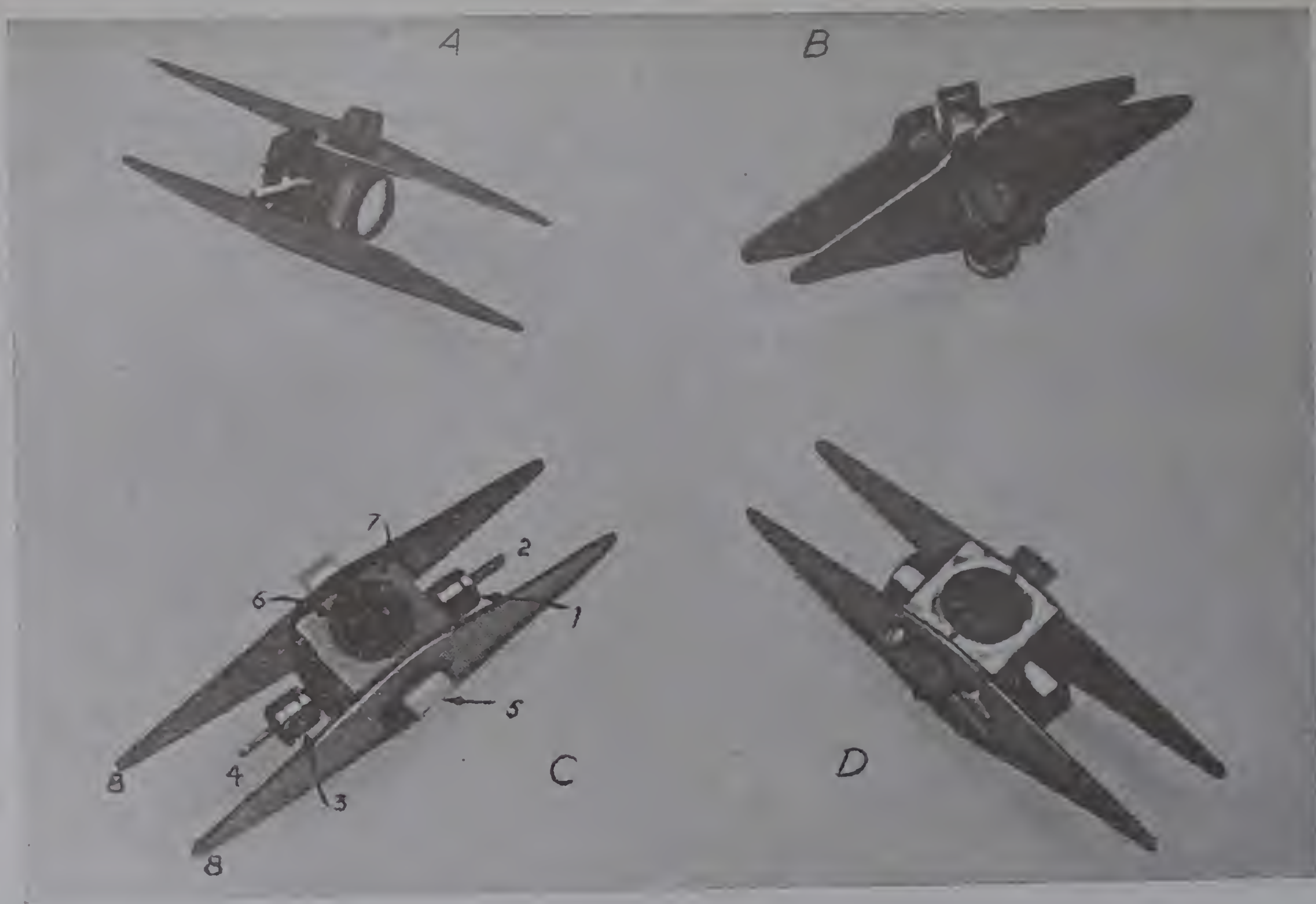


Fig. 56: (Bibl. No. 608, p. 95) Magnetic system of Askania magnetometers.
A — New-type, horizontal component, temperature-compensated system.
B — Uncompensated, horizontal component system.
C — New type vertical component, temperature-compensated system.
D — Uncompensated, vertical component system.
1 — Temperature compensation weight.
2 — Temperature compensation spindle (aluminium).
3 — Latitude adjustment weight.
4 — Latitude adjustment spindle (invar steel).
5 — Quartz knife-edge.
6 — Mirror.
7 — Aluminium frame.
8 — Magnets.

component of the earth's field by an opposing magnetic field created by an electric current.

Sub e. The *magnetron* is a diode or thermionic tube with a straight axial cathode surrounded by a cylindrical anode. In the presence of a magnetic field the electrons spiral around instead of travelling from cathode to anode.
After a critical magnetic field intensity is reached the electrons return to the cathode without reaching the anode. At this moment the plate current drops abruptly. This can be obtained artificially by changing the plate voltage V. Field-strength $F = \frac{6.72 \sqrt{V}}{r}$ if r = radius of the anode. By suitable orientation any component of the earth's field can be measured (see Bibl. No. 608, p.78).

1. B. 2. Methods used for relative values

a. Measurement of horizontal intensity: compass variometer

b. Measurement of magnetic gradient: magnetic torsion balance
magnetic gradiometer

Sub a. *Compass variometers* are used for measuring relative values of horizontal intensity and are composed of two disc-shaped magnets of equal magnetic moment suspended one above the other. Variations in angle between fine quartz rod-pointers attached to the magnet supports enable the observer to calculate $\triangle$ H. Readings of 1° indicate changes of the horizontal intensity of 75 gamma.

Sub b. *Magnetic torsion balances* use a magnet instead of the suspended weight in a gravitational torsion balance of EÖTVÖS (see p. 204), which normally measures the gravity gradient, i.e., the rate of change of gravity per unit of horizontal distance.

Magnetic gradiometers consist of two coils spaced apart, with parallel axes of rotation and rotatable at the same speed. If the field intensities perpendicular to the axes of rotation are different at the two coils, the relative magnitudes of the E.M.F. induced in the coils will depend on the relative magnitudes of the field intensities; this enables the observer to determine the magnetic gradient. The great advantage of this instrument is that it eliminates the effects of diurnal and other magnetic variations.

This short summary of the main magnetic methods may be sufficient indication to the non-geologically trained reader of the enormous amount of scientific work which has been and still is devoted to the scientific measurement of geophysical fields. It is therefore hardly possible for a non-highly physically trained dowser to develop a new instrument which would be unknown to the modern geophysicist.

The magnetometer, which does not measure the gradient directly, but only the difference in absolute values of the horizontal intensity in two neighbouring points, is able to register values as small as two gammas; this enables us to estimate a gradient of the order of 0.5 gamma/cm. An electric train passing at a distance of a mile or even more from the magnetometer creates a considerable disturbance in these sensitive instruments. The distances between the stations, in the case of regional survey, are generally 1 - 2 km, for local surveys generally not less than 10 m, although smaller distances could be used if necessary. The sensitivity of the magnetometer methods depends also on the corrections which always have to be made. Before the observed data of a magnetic suivey can be computed, a number of corrections are necessary, the most important being the *temperature correction* (1-3 gamma), *base station correction* (for instrumental changes), *diurnal variation correction* (2-5 gamma), *latitude and longitude corrections.* The latitude corrections amount to 10-12 gamma per mile for the vertical component (in the U.S.A.), 5-8 gamma per mile for the horizontal component (when movements proceed towards the north these values must be substracted for the vertical intensity, added

for the horizontal component). The longitude corrections amount to 2-3 gamma/mile (in the U.S.A.) (when eastward movement takes place, values being substracted for east declination areas and added for west declination). *Errors in scale reading* might also cause differences of 2-4 gamma. These few data on the correction of magnetic surveys are given to demonstrate the unscientific attitude of certain dowsers who claim they are able to determine the depth of an ore body by one simple reaction of the divining rod. No accurate results can be expected unless a number of corrections are made and this might explain the great number of failures of these so-called depth experiments of dowsers.

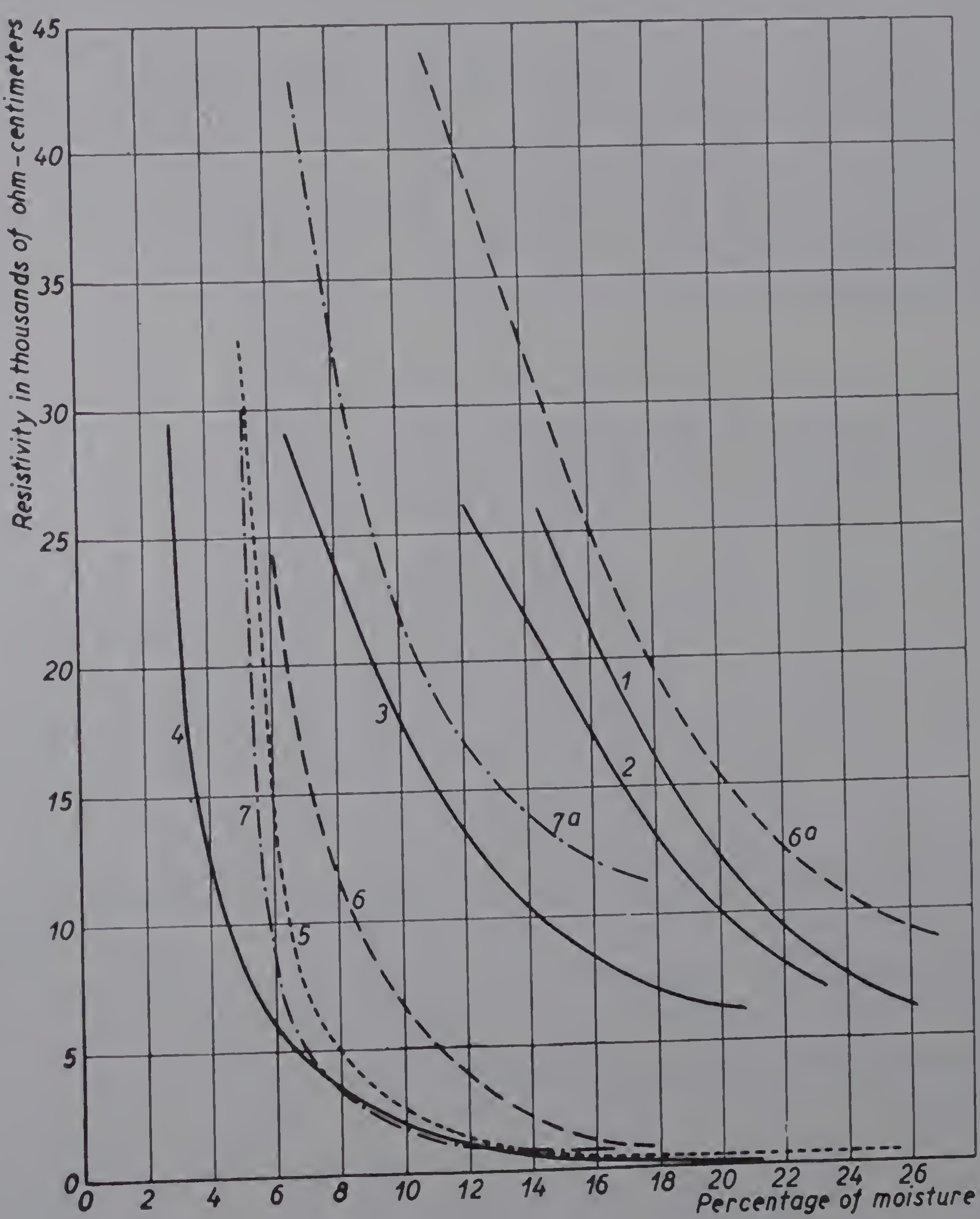


Fig. 57: (Bibl. No. 608, p. 251) Resistivity curves plotted against moisture percentages for various rocks (after JAKOSKY and HOPPER).

Curve 1 = Kaibab limestone; 2 = Coconino sandstone; 3 = Supai sandstone; 4 = Moencopic shales; 5 = altered granodiorite; 6 = fault gouge, 6a = leached gouge; 7 = fault gouge; 7a = leached gouge.

2. Electric field of the upper part of the earth crust

Origin of earth currents:

The electric fields in the earth crust are partly natural (a result of electro-chemical processes in the soil), partly artificial (due to artificial electric currents conductively or inductively flowing through the surface of the earth).

The magnitude and distribution of earth currents is determined by the *electro-chemical potentials* on the soil and the *resistivity* (or its reciprocal, the *conductivity*) of the rocks and minerals. These electrical potentials are considerably influenced at the earth surface by the differences in potential between the atmosphere (clouds, etc.) and the earth. These phenomena are discussed in part II of chapter I on the meteorological field.

Electric properties of rocks:

As unit of resistivity the *ohm-meter* (or centimetre) is used, the unit of conductivity is the *mho-meter* (or centimetre). Different rocks vary considerably in conductivity, the flow in non-metallic rocks being mainly *electrolytic*. This is indicated by the fact that rocks composed of poor conductors, such as quartz, felspar, etc., are often good conductors because of their moisture content. (see fig. 57).

Oil-impregnated rocks, which should have very high resistivities (crude oil being a very good insulator against electrical current) might have low resistivity values because of salt water impregnations.

In Bibl. No. 608, p. 254 a summary by JAKOSKY of the resistivity of different dry materials is given. A few values, important for dowsing, are shown here.

Minerals:	*Resistivity* (*in Ohm/cm*)
Anhydrite ($CaSO_4$)	$10^5 - 10^7$
Calcite ($CaCO_3$)	$> 10^7$
Chalcopyrite ($CuFeS_2$)	$1.5 \cdot 10^{-2} - 3.5 \cdot 10$
Chromite ($FeO.Cr_2O_3$)	$1 \cdot 10^2 - 2 \cdot 10^6$
Cuprite (Cu_2O)	$3 \cdot 10^4$
Diamond (C)	$1 \cdot 10^{14}$
Graphite (C)	$8 \cdot 10^{-4}$
Hematite (Fe_2O_3)	$5 \cdot 10^4 - 10^7$
Limonite ($Fe_2O_3nH_2O$)	$1 \cdot 10^5 - 1 \cdot 10^7$
Magnetite (Fe_3O_4)	$0.6 - 5 \cdot 10^3$
Marcassite (FeS_2)	$1 - 3.5 \cdot 10^2$
Muscovite ($H_2KAl_3Si_3O_{12}$)	$9 \cdot 10^4 - 9 \cdot 10^7$
Pyrite (FeS_2)	$5 \cdot 10^{-2} - 1 \cdot 10^{-4}$
Pyrrhotite (FeS)	$5 \cdot 10^{-2} - 5.0$
Quartz (SiO_2)	$> 10^7$
Rocksalt (NaCl)	$3 \cdot 10^3 - > 10^7$
Serpentine ($3MgO.2SiO_2.2H_2O$)	$2 \cdot 10^4 - 3 \cdot 10^5$
Sulphur (S)	$> 10^7$
Copper (Cu)	$10^{-6} - 10^{-1}$

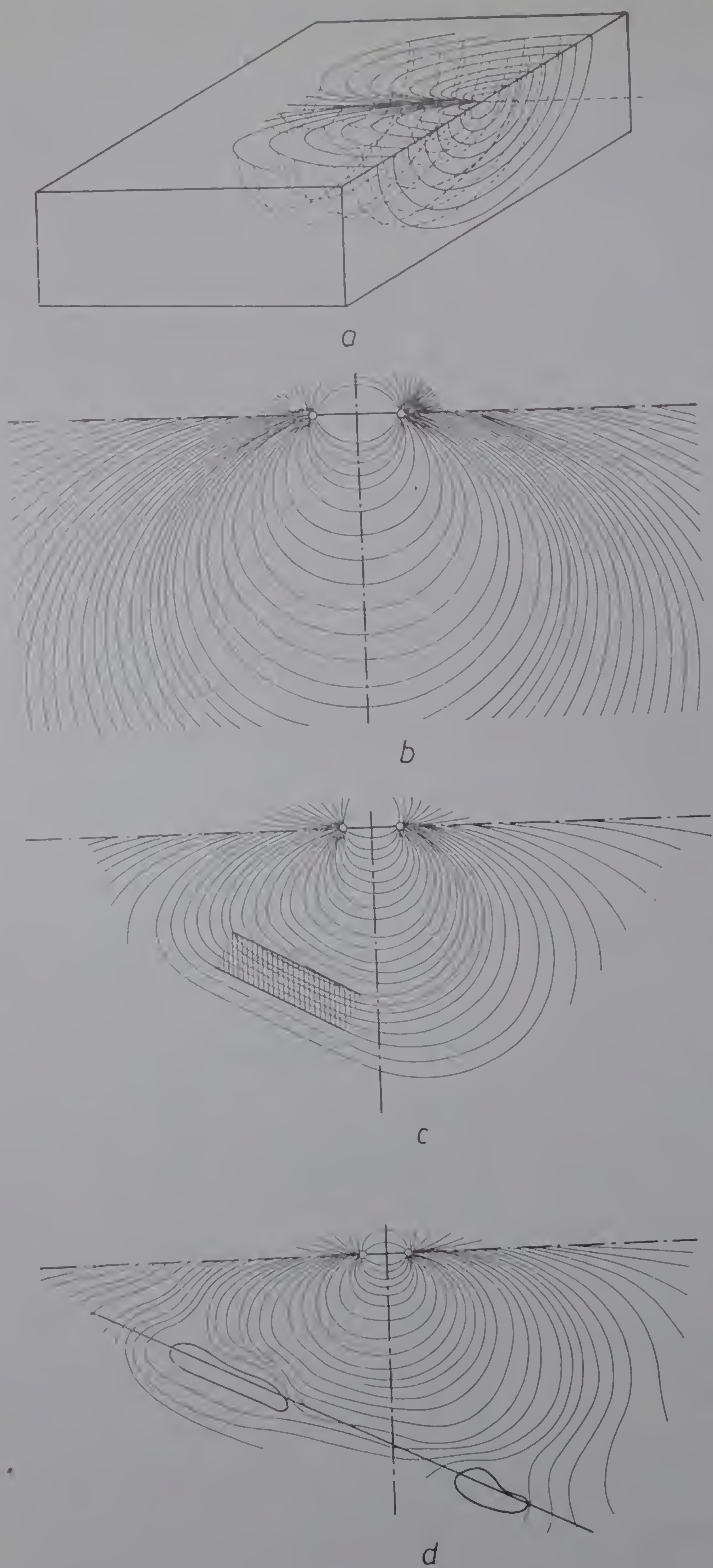


Fig. 58: (Bibl. No. 606, p. 572) Diagram showing deformation of equipotential lines in the soil caused by heterogeneous bodies.
a) Diagram showing distribution of equipotential surfaces on the upper part of the earth in the neighbourhood of two electrodes placed in the soil.
b) Distribution of equipotential lines in homogeneous soil.
c) Same, with a good conductor below the surface of the earth.
d) Same, with a poor conductor.

Sedimentary rocks	
Clay	$5 \cdot 10^2 - 1.5 \cdot 10^5$
Coal (bituminous)	$6 \cdot 10^1 - 10^7$
Coal (lignite)	$9 \cdot 10^2 - 2 \cdot 10^4$
Coal (anthracite)	$1 \cdot 10^2 - 2 \cdot 10^7$
Conglomerates	$10^3 - 10^6$
Limestone	$6 \cdot 10^3 - 5 \cdot 10^7$
Loams	$10^3 - 4.5 \cdot 10^4$
Marls	$0.5 \cdot 10^2 - 7 \cdot 10^3$
Sand	$9.5 \cdot 10^1 - 5 \cdot 10^5$
Sandstone	$3 \cdot 10^3 - 1 \cdot 10^7$
Shales	$8 \cdot 10^2 - 1 \cdot 10^6$
Slate	$6 \cdot 10^4 - 8 \cdot 10^4$

Igneous rocks	*resistivity* (in ohm/cm)
Granite	$3 \cdot 10^4 - > 10^6$
Syenite	$10^4 - 10^7$
Diorite	$5 \cdot 10^6$
Gabbro	$10^4 - 10^6$
Basalt	$2 \cdot 10^6$
Trachyte	$10^3 - 10^7$
Porphyry	$6 \cdot 10^3 - 10^6$

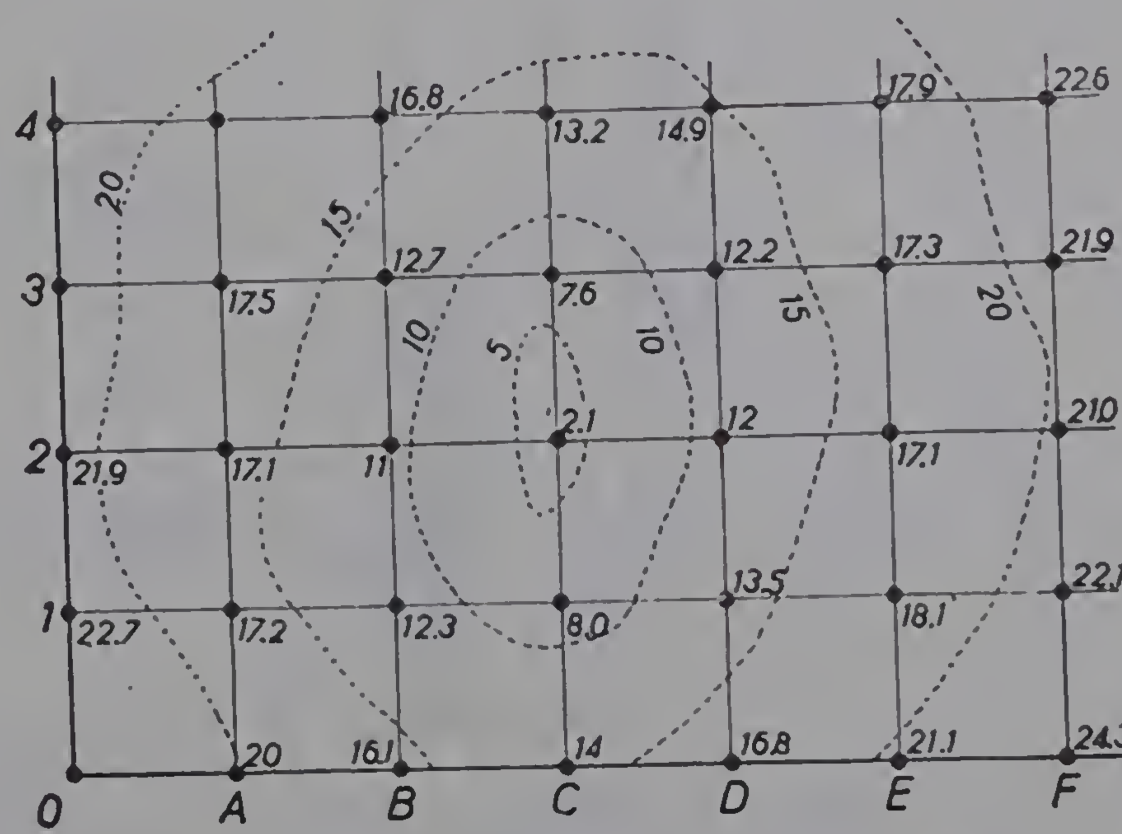
metamorphic rocks	*resistivity* (in Ohm/cm)
Gneiss	$2 \cdot 10^4 - 3.4 \cdot 10^6$
Marble	$10^4 - 10^7$
Quartzite	$10^3 - 2 \cdot 10^7$
Schists	$5 \cdot 10^2 - 10^6$
Serpentine rock	$2 \cdot 10^4 - 3 \cdot 10^5$

Because of the great influence of moisture on the conductivity of rocks it is evident that all factors which influence the porosity, permeability and water content of the soil influence also the magnitude and distribution of electric earth currents.

Equipotential surfaces:

The distribution of the electric earth currents shows up at the surface of the earth as lines of equal potentials. The presence of heterogeneous bodies with conductivity differing from the surrounding rocks creates deformations in the equipotential surfaces (see fig. 58).

In the case of circulating ground water and oxidisable ore bodies, electro-chemical currents are formed, the upper part of the ore body being the positive pole; the electrolyte is composed of the weak acids formed during oxidation (see fig. 59). The current usually flows downward,



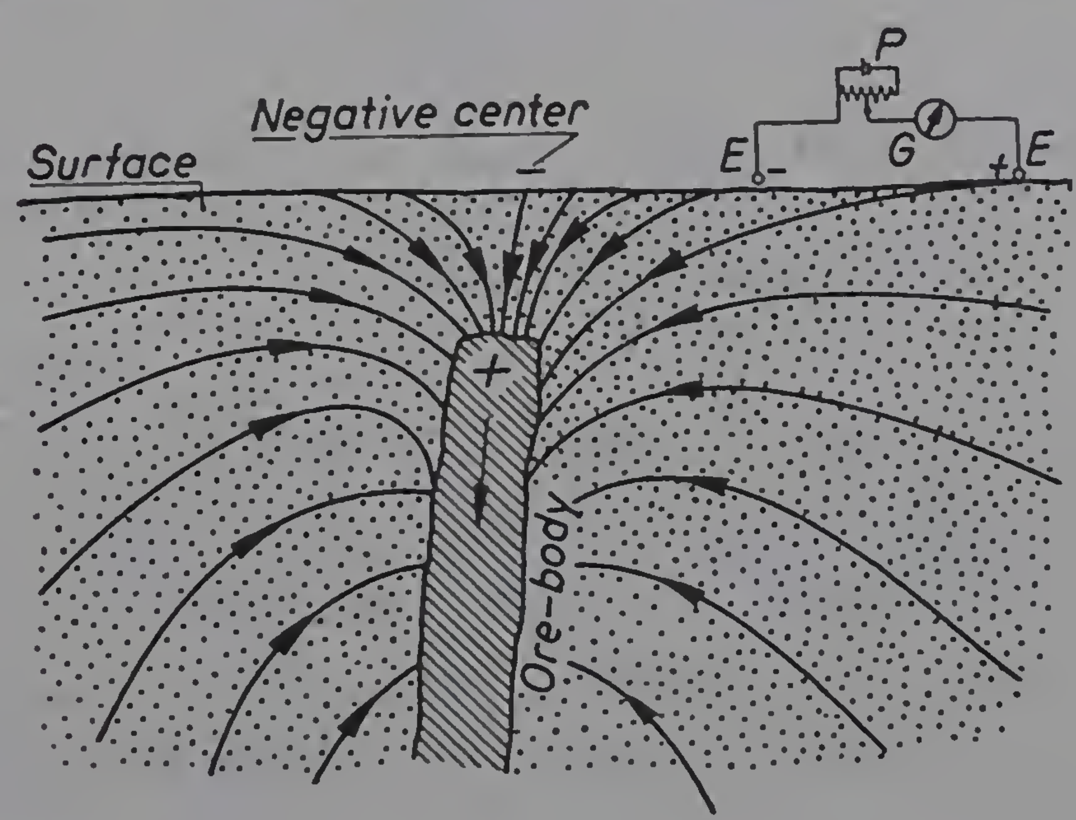


Fig. 59: (Bibl. No. 608, p. 257) Distribution of equipotential lines and position of negative centre above a vertical ore body.

first within the ore body and then upward again through the surrounding earth. These returning currents spread outward over considerable distances as a result of the high resistances in the soil. At the surface of the earth they flow toward a point — the *negative centre* — usually situated above the ore body (see fig. 59). In areas with irregular topographic conditions, however, the distribution of surface potentials is less regular and the negative centre might be shifted, usually toward the hanging-wall side of the ore body (see fig. 60).

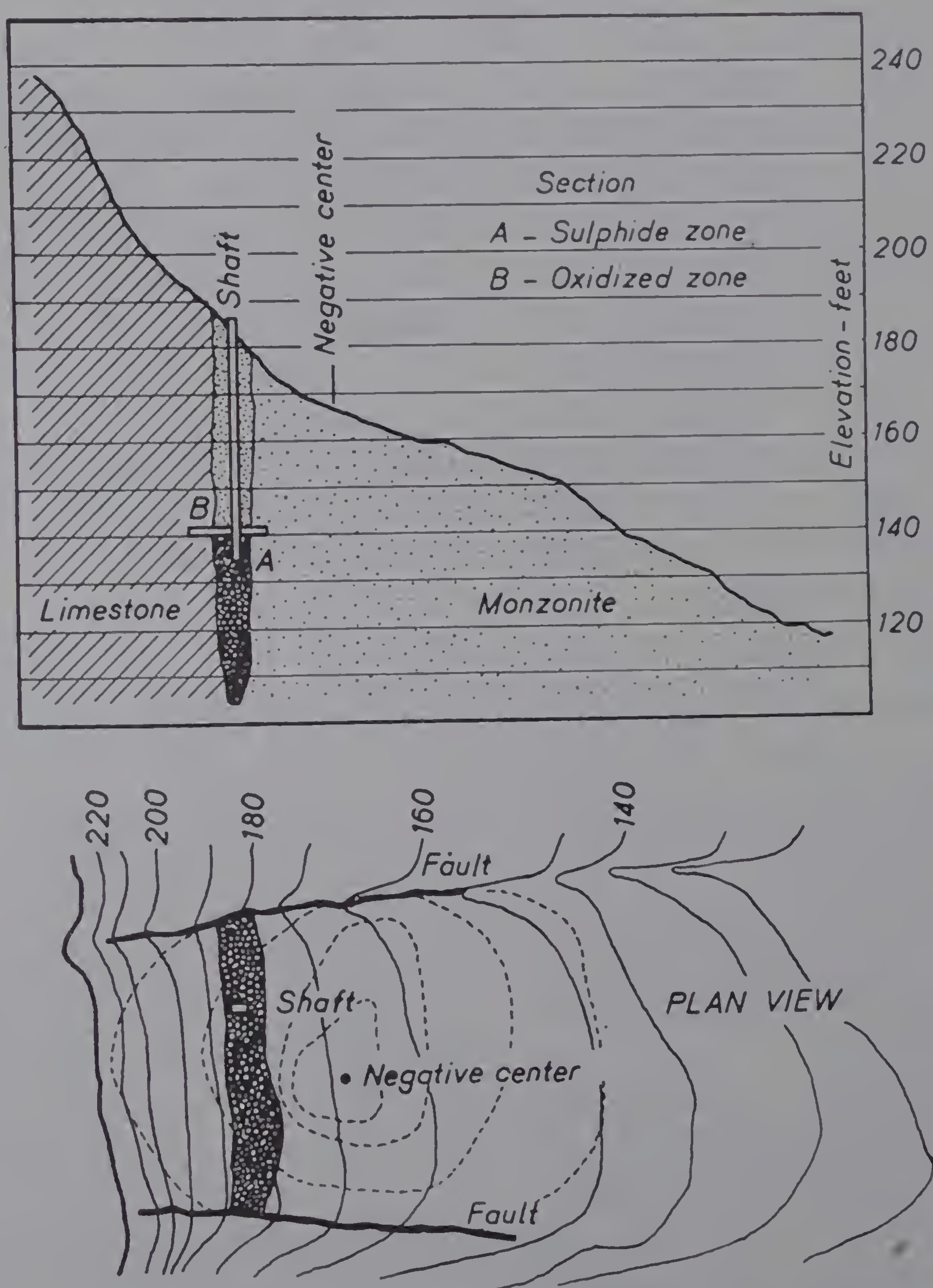


Fig. 60: (Bibl. No. 608, p. 263) Diagram illustrating the displacement of the negative centre with respect to the top of the ore body. Equipotential lines, dotted; topographic contours, solid.

In the ideal case of a vertical ore body, surrounded by an homogeneous medium with uniform moisture content and ground water level, the equipotential lines on the surface of the earth would be a set of concentric circles, the centre being the "negative centre". The direct-current potential differences may be as great as 500-1,000 mV per km and

are measured between two non-polarizable electrodes placed in the soil (see later).

Resistivity curves:

When an artificial current is passed through two electrodes in the soil and the resistance is measured between two other auxiliary electrodes placed at different points in the neighbourhood, lines of equal resistivity can be obtained. The diagram in fig. 61 shows the form of a resistivity

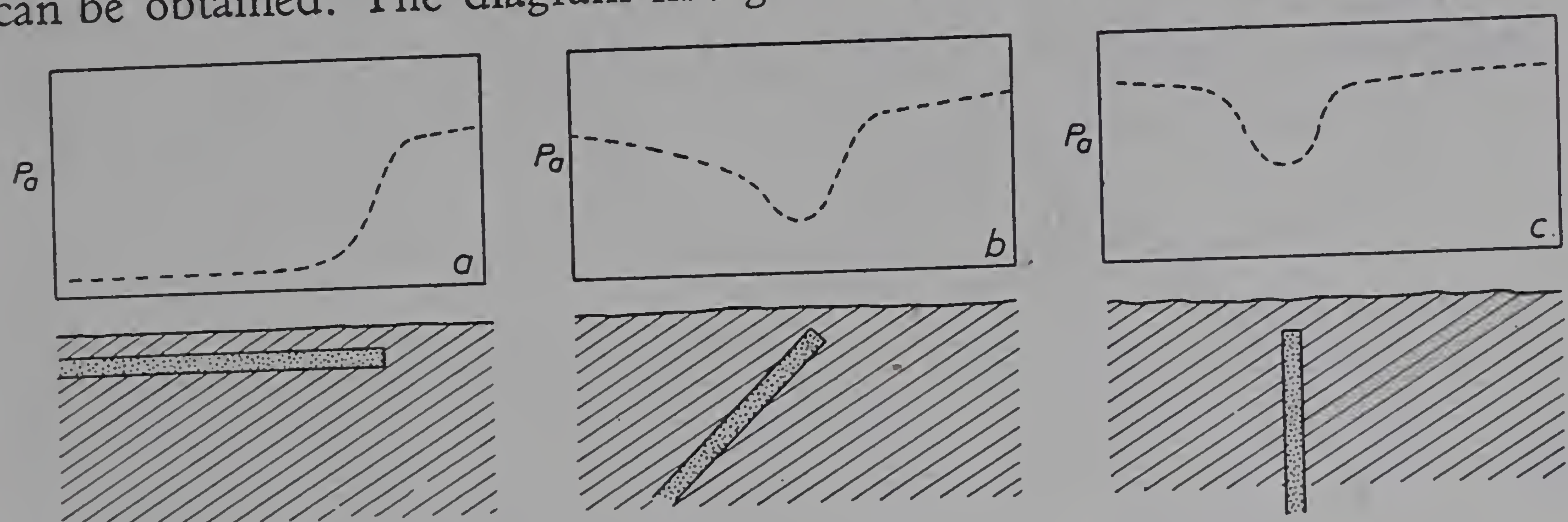


Fig. 61: (Bibl. No. 608, p. 171) Diagram showing the relationship between resistivity curves and position of conducting bodies in the soil (after C. H. WILSON).

curve in a profile above a conducting body in the soil. The effective depth of current penetration depends largely on the relative conductivities of the sub-surface strata. The ratio between the effective depth of penetration and the distance between the two power electrodes is termed the *penetration factor*. It is greatly influenced by the presence of a good conductor in the soil (see fig. 62). At electrode distances (L) less than d (= distance of conductive layer below the surface) the influence of the conducting layer is small, the penetration factor being relatively small. If L is slightly more than 2d, caused by the downward bending of the currents toward the conductor, the highest penetration factor is obtained. If L is much larger than 2d the currents tend to be confined to the highly conducting layer and the penetration factor decreases again.

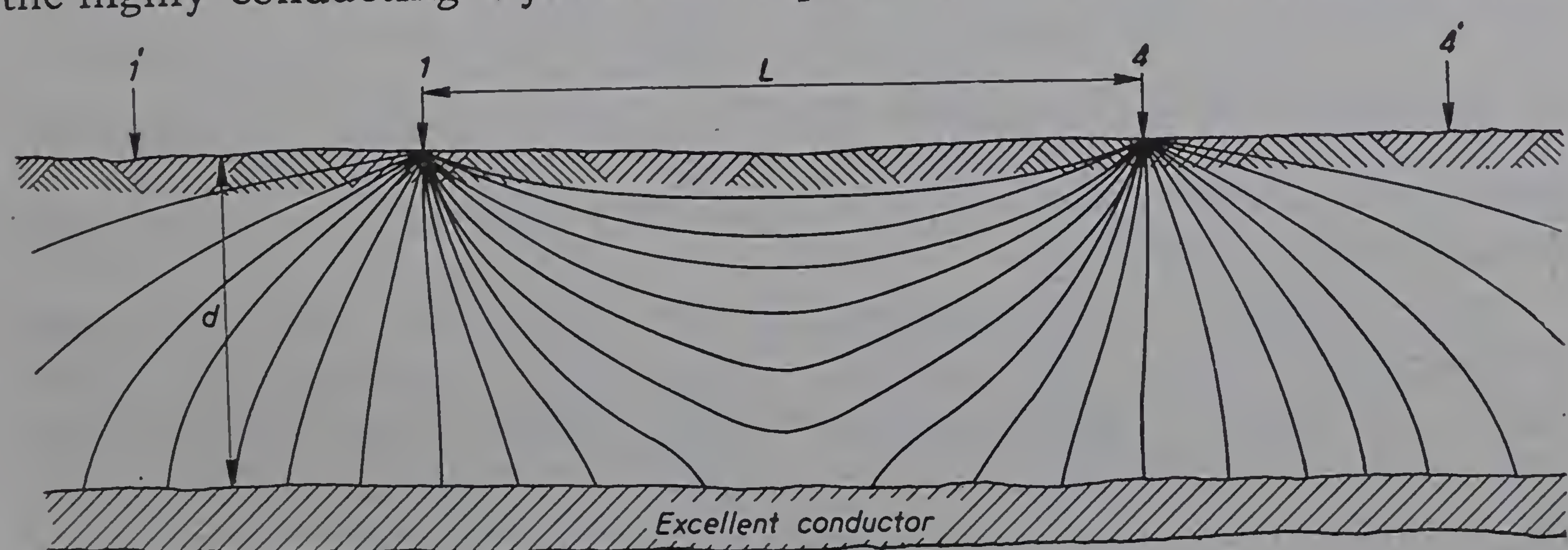


Fig. 62: (Bibl. No. 608, p. 323) Sketch illustrating current paths for a structure comprising a layer of high resistivity overlying a good conductor.

Measurement of depth and configuration of a buried body:

The best geophysical results are usually obtained when the variations of the physical quantity measured at the surface of the earth are proportional to the depth of the body. In electric methods, however, the depth is not dependent only on the vertical depth of the marker. In fig. 63, part A, a small, relatively steeply dipping structure is indicated; fig. B shows a large, flat-lying body. The detectability of these structures depends on the effective volume of the structure included in the current-lines. Both A and B could give the same electric anomalies, although their reliefs and depths below the surface are different.

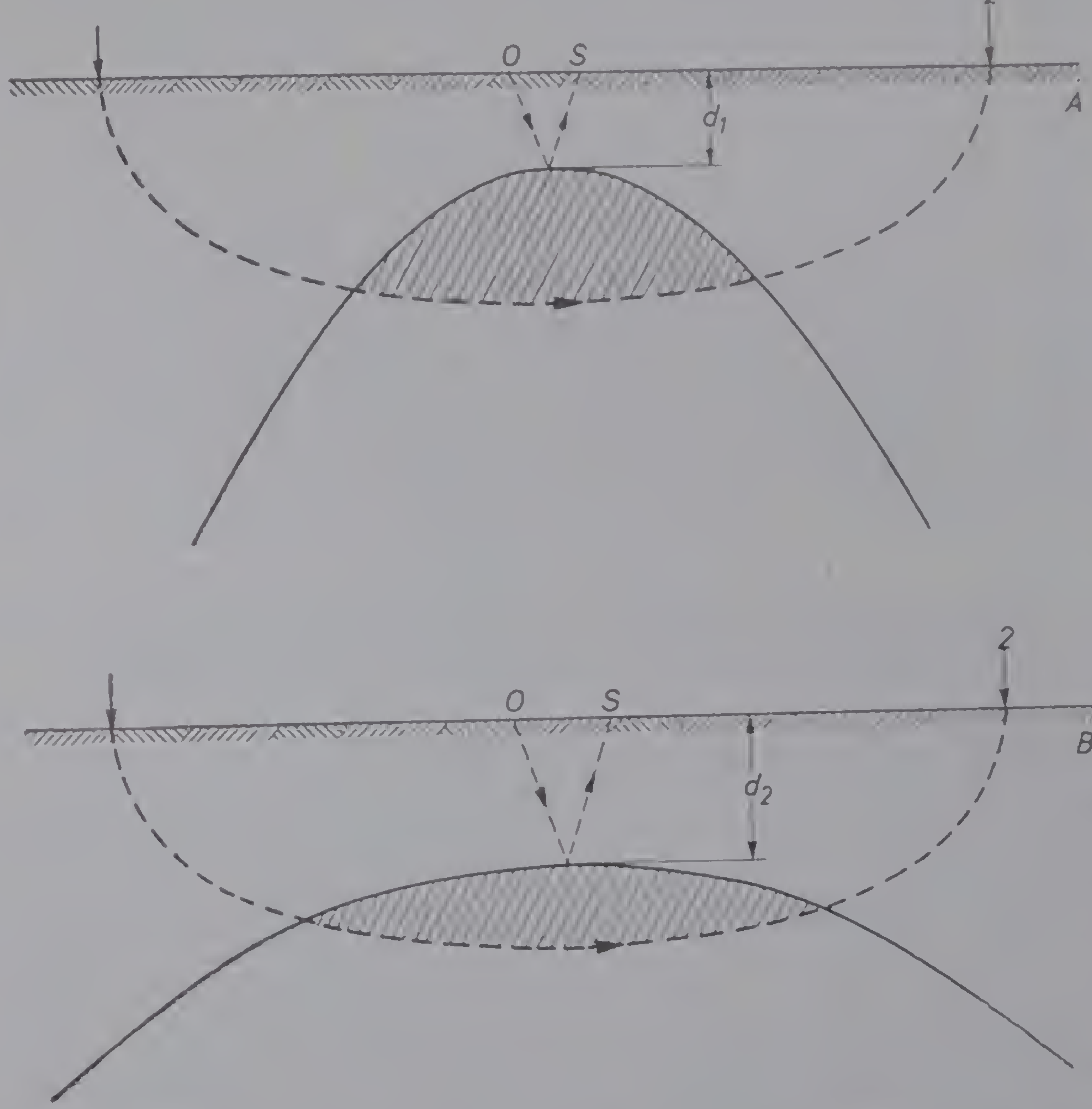


Fig. 63: (Bibl. No. 608, p. 322) Diagram illustrating concepts of depth of penetration and detectability.

Influence of anisotropic media:

Electric currents in stratified rocks propagate more easily along the strike (i.e., the direction of the beds) than in a direction perpendicular to it. In order to be able to take this influence into account, the *coefficient of anisotropy* (λ) is introduced. $\lambda = \frac{\sqrt{r_t}}{r_l}$, r_t = resistivity along the strike (transverse resistivity); r_l = resistivity perpendicular to the strike (longitudinal resistivity).

In an isotropic homogeneous soil the equipotential surfaces around a source of current are spheres. In anisotropic homogeneous media the equipotential surfaces are rotational ellipsoids with rotational axis through the electric source perpendicular to the strike. The ratio of the semi-axes of the ellipsoid (longest axis: shortest rotational axis) is equal to the coefficient of anisotropy (λ).

These phenomena should be taken into consideration before the measured value can be computed, which shows again that a dowsing

reaction cannot be interpreted without previous corrections of the observed forces.

A. Causes of variations of the electric field

We have seen that the normal distribution of equipotential lines at the surface of the earth, due to an ore body for example, is determined by the electrolytic properties of that body, the size, configuration and depth below the surface. This normal picture is often disturbed by a great number of phenomena, which can be divided into four groups: atmospheric causes, geological causes, magnetic causes, artificial causes.

2. A. 1. Atmospheric causes

We have seen that the conductivity and rate of oxidation in the soil depend greatly on the moisture content. The atmospheric causes can thus be divided into two groups: variations of the electric field of the surface of the earth, due to changes in atmospheric electric conditions and changes in moisture content.

a. *Changes in the electric field of the atmosphere:* this is discussed on p. 249 and can therefore be omitted here. It is evident that all periodical and non-periodical fluctuations (such as changing earth potential below clouds) of the electric field of the atmosphere are reflected in the electric fields of the soil.

b. *Changes in moisture content:* rain, snow, frost, fluctuations in surface temperature and atmospheric pressure can alter the moisture content of the surface rocks to a considerable extent.

2. A. 2. Geological causes

A great number of geological conditions are responsible for variations in the observed surface potentials.

a. *Local changes in composition of the rocks:* either variations in mineral content or in porosity and permeability.

b. *Fluctuations in ground water level:* deep ground water level and high resistivity of covering soil create small surface potentials.

c. *Distribution between land and water:* lakes, rivers, ditches, etc., considerably influence the distribution of surface potentials because they in turn influence the ground water level, the moisture content of surrounding areas, the shape of equipotential surfaces, etc.

d. *Topography:* we indicated on p. 228 (fig. 60) the influence of topographic conditions on the positions of the "negative centre".

e. *Regional gradient:* often related to atmospheric phenomena (see also fig. 41). This can amount to 10-100 mV per km, depending on the place on earth and the time of the year.

f. *Geologic structures:* faults, folds, presence of ore bodies, stratification of rocks, etc., influence the anisotropic effect.

2. A. 3. Magnetic causes

A great number of more or less periodical fluctuations of the earth potential occurs; these are closely related to the fluctuations of the magnetic field of the earth. Although the name "magnetic causes" is strictly speaking incorrect, we use this expression to indicate the close relationship. Diurnal, thirteen day, lunar, yearly and secular variations, magnetic storms and eleven-year periods show up in the fluctuations of the electric potentials of the surface of the earth.

2. A. 4. Artificial causes

Presence of rails, sub-surface or surface pipes, leakage of power circuits, etc., may create considerable local disturbances in the electric field of the surface of the earth, even at distances of up to a mile from the source.

B. Methods and instruments for measuring the electric field of the surface of the earth

Jakosky (Bibl. No. 608, p. 252) and Ansel (Bibl. No. 606, p. 502) have given an excellent summary of the different electric methods used in geophysical exploration work. A brief summary of these methods and of the general principles on which they are based is required in order to facilitate the evaluation of dowsing phenomena which, as we show on p. 361, are closely related to variations in the electric field of the surface of the earth.

I. *Conductive methods:*

- A. Methods applicable under steady state conditions:
  1. Self-potential or spontaneous polarization method (see fig. 64)
  2. Direct current equipotential line method
  3. Low-frequency alternating current equipotential line method
  4. Resistivity methods (see fig. 65)
- B. Methods applicable under moving field conditions:
  1. Medium frequency alternating induction current method
  2. High frequency alternating induction current method

II. *Electro-magnetic methods:*

- A. Methods using conductive energizing sources
  1. Direct current method
  2. Low-frequency alternating current method

  } using variometers, magnetometers, etc.

  3. High-frequency alternating current or search-coil method: using direction finders (see fig. 66)
- B. Methods using electro-magnetic energizing sources: horizontal loop method, vertical coil method (see fig. 67)

1. Absorption method
2. Reflection method
3. Reflection and interference method
4. Capacitive method

Conductive methods include all methods which measure only the electric properties of the field; both the energizing and measuring electrodes make direct contact with the ground, the energizing current being either direct or alternating.

The electro-magnetic methods include all methods which measure the magnetic field associated with the flow of an electric current.

Whereas in the method sub IA steady relations exist because of the direct current conditions, in the group of methods, sub IB, we must take into account variables such as phase shift, polarization ellipse, impedance (instead of resistivity, see p. 184), redistribution of currents caused by inductive effects, etc.

The "medium frequency methods" use frequencies of 50-500 cycles/sec; the typical high-frequency methods use frequencies of a few thousand cycles/sec up to radio frequencies (see p. 62).

The *self-potential method* measures the natural flow of current in the earth. A base station is first selected. The *galvanometer* (with a sensitivity to direct currents of 0.25-2 μA and resistance of 1,000 ohm or more, for minimizing the effect of contact resistances between electrodes and the earth) and tripod are set up near this station (see fig. 64) and connected by a 20 ft insulated cable to a non-polarizing electrode buried at the station. The other electrode (non-polarizable) is connected to the instrument by a 250 ft long insulated wire and placed in the soil at a distance of 100-200 ft from the first electrode. The potential difference is noted and the electrode then moved to different points until a place is found that gives no potential

Fig. 64: (Bibl. No. 608, p. 259) Equipment used for measuring earth potentials. a) non-polarizing electrode, b) potentiometer, c) tripod, d) anchor stake, e) reel.

difference. The galvanometer is moved to this second point and then so on till the whole equipotential line is traced.

Another method establishes for a great number of points the potential differences with the base station and afterwards constructs the equipotential lines.

Potential differences are also measured directly with a potentiometer with a range of 0-1,000 mV.

In the *direct current equipotential method* an artificial current is passed through the electrodes; these are made rather long in order to minimize contact resistances.

Power is usually supplied by a gasoline-driven direct current generator with an output of 1,500-2,000 W and a voltage up to 220 V. Less power is required in the case of alternating currents (sub IA3). From the resultant field the undisturbed natural earth field must always be deducted.

The field procedure employed in the *resistivity method* consists of passing a measured current through two selected points of the earth and measuring the potential drop between two auxiliary electrodes; the 4 electrodes are generally placed in a straight line (see fig. 65).*

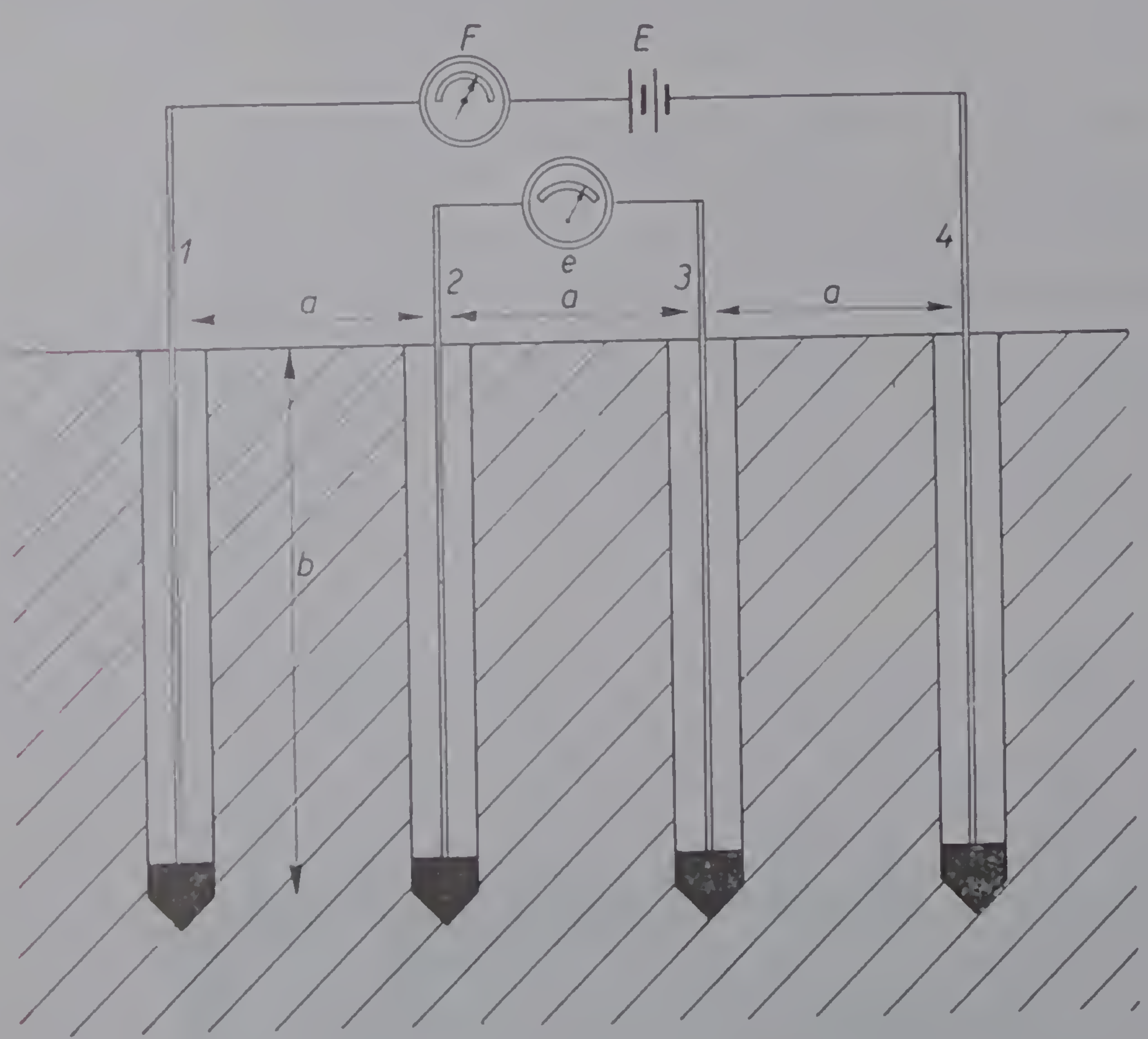


Fig. 65: (Bibl. No. 606, p. 575) Measurement of electric resistance of the soil (after WENNER). E = electric source, F = galvanometer, e = voltmeter.

Sub IIA. In these methods direct or alternating current is passed into the soil between two electrodes and the surface effects then studied by analysing the magnetic field. In the case of direct current or low-frequency alternating current the magnetic field is measured with *variometers* or *magnetometers*; if medium or high-frequency alternating currents are applied, a *direction-finding* or *search coil*, with amplifiers and phase compensating apparatus, is used (see fig. 66).

Sub IIB. In these methods an alternating current is induced in subsurface strata by passing high or medium frequency alternating currents through an energizing coil or loop mounted on the surface of the earth,

* If the earthcrust is homogeneous the average resistivity (ϱ) is calculated as follows: $\varrho = 2\pi a \frac{V}{I}$, if a current of I ampères is passed between the two outer electrodes, the potential difference between the two inner electrodes = V and if a = electrode separation.

orientated either in a horizontal or vertical position (see fig. 67).

The *absorption method* is based on the principle that a good conductor between transmitter and receiving station absorbs all the electro-magnetic waves.

The *reflection method* uses the reflection of electro-magnetic waves by conducting bodies in the soil.

The *reflection and interference method* is based on the principle that a maximal reception of the reflected waves is obtained if the distance between transmitter (and receiving station) and the body is $\frac{1}{4}\lambda$ of the reflected waves.

The *capacitive method* is based on the fact that, in condensers, substances with high dielectric constants increase the capacity; the same holds for the neighbourhood of conductors; in the latter case the damping effect is increased.

The instruments used consist of a vibrating circuit of which the capacity is a function of the dielectric constant of the soil; aerial and soil together form a kind of condensor; the presence of conductors in the soil cause a damping effect. The measurement consists of establishing the frequency and damping of the vibrating circuit.

Fig. 66: (Bibl. No. 608, p. 397) Electromagnetic direction-finding apparatus for high frequencies. A = mounting head; B = alignment sights; C = graduated arc for reading vertical angle; D = adjustment screw; EF = vertical rotation axis; G = azimuth scale; H = ball and socket plate; I = battery compartment; J = voltmeter; K = headphones.

The dielectric constants of a few important substances are (acc. to Ambronn): granite 8, basalt 12, porphyry 13, gneiss 14, micaschists 16, sandstones 9-11, limestone 8-12, anhydrite [6-7, rocksalt 5.5-6.3, petroleum 2, ice 1.8.

The alternating current used in the *horizontal loop method* is usually generated by a gasoline-driven alternator with a magnitude of 5-20 ampères and for shallow investigations with a frequency of

500-1,000 cycles/sec. The size of the energizing horizontal loop on the ground is generally 1,000-2,500 ft on a side. The observations consist in determining contours of equal magnetic flux anomaly, which is normally achieved by using two search coils opposingly connected. One coil is left at the base station; the second is moved until a position is found where the induced potential between the two coils is minimum.

The *vertical coil method* uses frequencies of 30,000 cycles/sec to 50 kC The dimensions of the coil (see fig. 67) are about 7×7 ft; the coil is supported by 10 ft long cross pieces (see fig. 67 b) and is mounted on a tripod.

Those readers interested in further details of the theory of electro-magnetic surveying are referred to the original publications mentioned in Bibl. No. 604a-612.

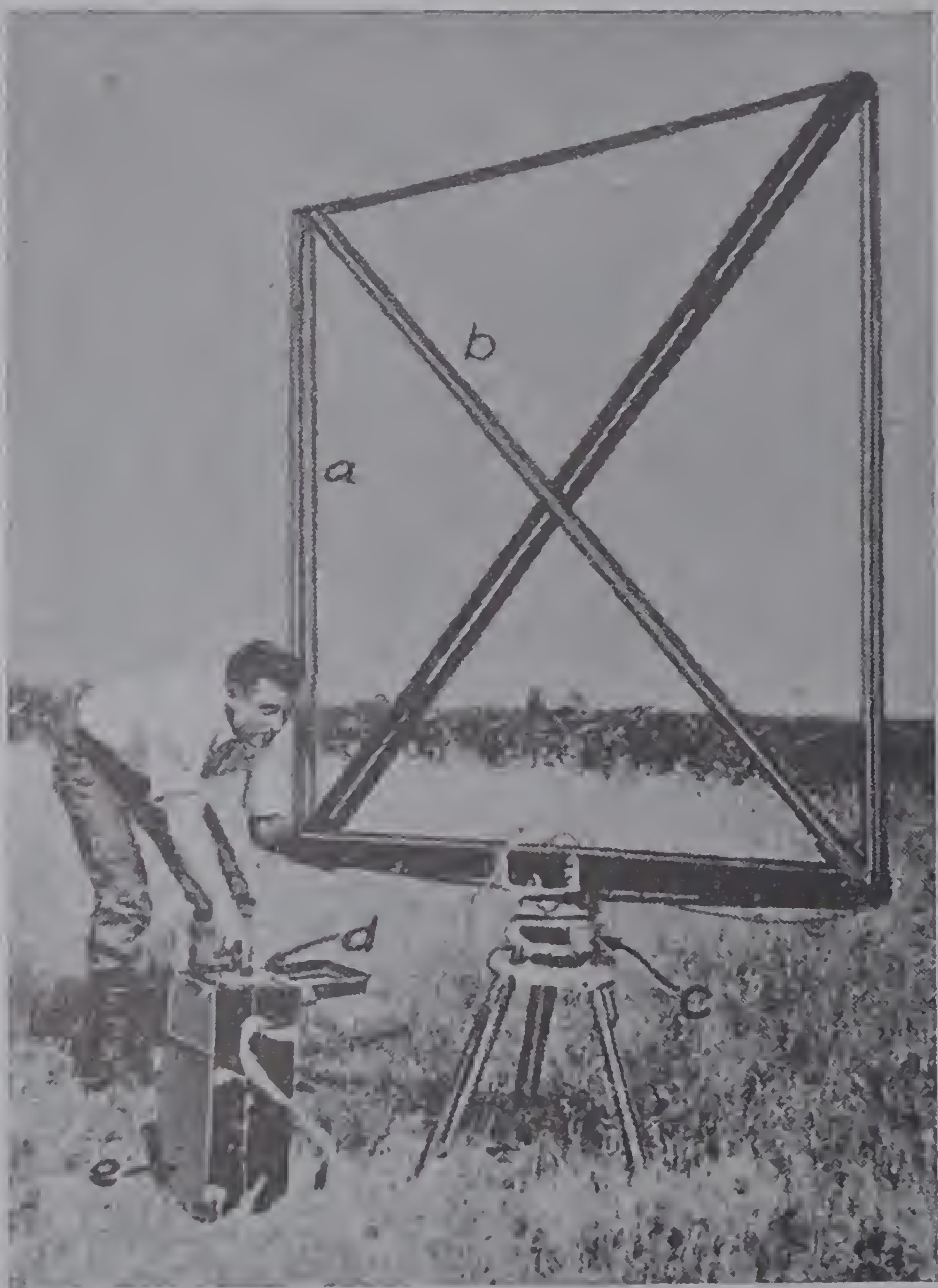


Fig. 67: (Bibl. No. 608, p. 419) High frequency energizing system in operation: a = high frequency coil; b = folding coil support; c = tripod head allows rotation about vertical axis; d = high frequency oscillator; e = battery compartment.

3. Radioactive field of the upper part of the earth crust (see Bibl. No. 607a, 608a and b)

From the different properties of radioactive substances in the upper part of the earth crust only their ionization capacity seems to be of importance for living bodies and the problem of dowsing.

The average radioactive content of rocks is abt. 10^{-12} g Radium, abt. 10^{-6} g Uranium and 10^{-5} g Thorium/g rock. When we learn that the development of heat of 1 g Uranium in a year = 0.79 gcal, of 1 g Thorium = 0.21 gcal and of Radium (if completely in equilibrium with all its disintegration products) = 138 cal/h, it is evident that these heat quantities are negligible compared with other thermal processes in the porous upper part of the earth crust. The influence of potassium, considered as a radioactive element is also negligible, the heat production per year of 1 g K being only $1.24 \cdot 10^{-4}$ cal.

A. Radioactive content of the lithosphere

A great number of rocks have been analyzed, particularly by R. J.

STRUTT (1905), A. S. EVE, and D. MAC INTOSH (1907). The following average values were obtained:

3. A. 1. Igneous rocks

average value $1.7 \cdot 10^{-12}$ g Ra/g rock. Ra content decreases with decreasing acidity of the rocks.

Granite: 3.3 - $4.8 \cdot 10^{-12}$ g Ra/g rock.
Syenite: $2.44 \cdot 10^{-12}$ (Norway)
Peridotite: $0.68 \cdot 10^{-12}$ (Island Rum)
Dolerite: $0.62 \cdot 10^{-12}$ (Island Canna)
Basalt: 0.3-$0.6 \cdot 10^{-12}$
Serpentine: $0.5 \cdot 10^{-12}$ (Cornwall)
Dunite: $0.33 \cdot 10^{-12}$ (Loch Scaivig)

According to J. JOLY (1912) and J. H. J. POOLE (1915), who repeated these analyses, the following average values occur:

Trachyte:	$3.0 \cdot 10^{-12}$ g Ra/g rock;	$1.79 \cdot 10^{-5}$ g Th	(average of	18 rock types)
Granite:	$2.7 \cdot 10^{-12}$,, ,, ;	$2.0 \cdot 10^{-5}$,,	,, ,,	63 ,, ,,
Syenite:	$2.4 \cdot 10^{-12}$,, ,, ;	$1.7 \cdot 10^{-5}$,,	,, ,,	12 ,, ,,
Diorite:	$1.6 \cdot 10^{-12}$,, ,, ;	$0.99 \cdot 10^{-5}$,,	,, ,,	8 ,, ,,
Basalt:	$1.4 \cdot 10^{-12}$,, ,, ;	$0.56 \cdot 10^{-5}$,,	,, ,,	18 ,, ,,
Gabbro:	$1.3 \cdot 10^{-12}$,, ,, ;	$0.50 \cdot 10^{-5}$,,	,, ,,	5 ,, ,,

3. A. 2. Sedimentary rocks

a. *Shallow water sediments*:

Oölites (of Bath): $2.92 \cdot 10^{-12}$ g Ra/g rock (acc. to STRUTT and EVE)
Marble (East-Lothian): $1.93 \cdot 10^{-12}$
Clay (Essex): $0.86 \cdot 10^{-12}$
Sandstone (E. Lothian): $0.84 \cdot 10^{-12}$
Flint (Essex): $0.53 \cdot 10^{-12}$
Limestone (Cambridge): $0.39 \cdot 10^{-12}$

Later studies by J. JOLY (1910) and A. L. FLETCHER (1912) indicate the following averages values:

Sandstone:	$1.5 \cdot 10^{-12}$ g Ra and	$0.6 \cdot 10^{-5}$	g Th./g rock.
Clay:	$1.3 \cdot 10^{-12}$,, ,, ,,	$1.3 \cdot 10^{-5}$	,, ,, ,, ,,
Limestone:	$0.5 \cdot 10^{-12}$,, ,, ,,	$< 0.05 \cdot 10^{-5}$	,, ,, ,, ,,

b. *Deep water sediments*: values based on studies of J. JOLY (1908). Ra content generally increases with decreasing lime content and decreasing speed of sedimentation.

Globigerina ooze:	$6.7 \cdot 10^{-12}$ g Ra/g	sediment	(92.54%	$CaCO_3$)
,, ,, :	$7.4 \cdot 10^{-12}$ g Ra/g	,,	(64.34%	,,)
Red deep-sea ,, :	$15.4 \cdot 10^{-12}$ g Ra/g	,,	(28.28%	,,)
,, ,, ,, ,, :	$52.6 \cdot 10^{-12}$ g Ra/g	,,	(12.00%	,,)
Radiolarian ,, :	$22.8 \cdot 10^{-12}$ g Ra/g	,,	(10.19%	,,)
,, ,, :	$50.3 \cdot 10^{-12}$ g Ra/g	,,	(3.89%	,,)

It has been found that the Uranium content of rocks is abt. $3 \cdot 10^{6}$ larger than the Ra content. The Thorium content is of the order of 10^{-5} g/g rock.

According to J. B. OSTERMAIER, o.a., petroleum and other organic deposits in nature are often considerably richer in radioactive substances than neighbouring rocks, probably because of the great occluding capacity of organic substances.

B. Radioactive content of the hydrosphere

The average Radium content of sea-water is abt. $0.017 \cdot 10^{-12}$ gr./gr. water. The content of river water and lakes is generally very small too. The content of hot water springs is sometimes considerably larger than any rock value.

C. Ionization capacity of radioactive substances

We mentioned on p. 62 and 63 some of the most important ionization properties of α, β and γ rays. The air, present in the pores of the soil and in larger subterranean cavities, is continuously ionized:
1. By direct irradiation with α, β and γ rays of radioactive minerals present in the surrounding rocks; because of the considerable absorption of those rays (particularly α and β) by surrounding minerals, this influence is generally very small; nevertheless, γ rays have sufficient penetration power to pass through iron pipes of several inches thickness; this property is utilized in well-logging (i.e., determining the nature of the rock in a drilled hole), the γ radiation being measured with specially constructed Geiger-Müller *counters* which can be lowered in a drill-hole.
2. By indirect radiation, created by volatile radioactive substances (Ra and Th emanation); Radium emanation disintegrates into half its original volume in abt. 3.825 days, Thorium emanation in 54 seconds. 1 g of Radium extrudes $3.4 \cdot 10^{10}$ α particles per sec. Their penetration distance in air is 3-8 cm and they create abt. 10^5 ions per α particle. If we assume that all α particles extruded by Radium present in 1 g of granite rock are able to ionize, the total number of ions developed per sec would be $2.5 \cdot 10^{-12} \cdot 3.4 \cdot 10^{10} \cdot 10^5 = 8.5 \cdot 10^3$ ions. Although only part of the α particles can ionize and considering the fact that Radium emanation (not Radium) is probably the main ionizing factor in the soil, it is evident that the combined action of α, β and γ rays even of these small traces of radioactive substances might have a certain significance for organic life since we constantly inhale the ionized air of our immediate surroundings (see chapter II, part II).

D. Causes of variations in radium-emanation content of the lithosphere

A great number of factors influence the amount of air in the soil and as a direct result the radium-emanation content (the average content in the atmosphere is $6 \cdot 10^{-18}$ %):

1. Metereological factor:
   a. periodical fluctuations:
      α. depending on the hour of the day
      β. depending on the period of the year

b. non-periodical fluctuations:
 α. temperature
 β. atmospheric pressure and wind
 γ. precipitation (rain, snow, ice);

both α and γ influence considerably the porosity, permeability and texture of the soil.

2. Depth below the surface.
3. Topography.
4. Geological structure: according to R. AMBRONN and H. HIRSCHI increased circulation along faults causes increased radioactivity and ionization of the air in the soil above, even if a thick sedimentary layer covers a fault in underlying massive rock.

E. METHODS USED FOR MEASURING THE EMANATION CONTENT

A series of shallow holes are made with special drilling outfits — *hand augers*. These holes are then closed and kept so for some time in order to re-establish the normal emanation equilibrium in the soil. A tap in the hole-cover allows the air in the hole to be pumped out later; after being dried the air passes the ionization chambers and the ordinary instruments for measuring the rate of ionization of gases.

4. Geochemical field of the upper part of the earth crust

We discussed on page 32-54 the sensitivity of colloidal substances to volatile matter (RUSSELL- and STEMPELL effect). On p. 101-106 we mentioned the enormous sensitivity of animal and man to chemical excitation and the capacity of smelling in particular. We saw on p. 104 that different geological and meteorological factors influence the sense of smell. All these facts invite a review on this modern geophysical method, which we described on p. 205 as geochemical methods.

A. VOLATILE COMPONENTS OF THE EARTH CRUST

The vapours of the soil can be classified in the following groups:

1. *Volcanic regions:* apart from great quantities of water vapours, volcanic regions are mostly rich in the following gases: S, H_2S, SO_2, HCl, Cl_2, CO, CO_2. CH_4, H_2, N_2, O_2, H_3BO_3, Fe_2Cl_6, $AsCl_3$; traces of H_2SO_4 and NH_3 also occur. They derived originally from the fluid magma present under the volcanic regions. In regions where volcanic phenomena still occur as volcanos, solfatara or fumaroles, the composition of the soil-gases and the rate of extrusion is greatly dependent upon the temperature of the magma and volcanic liquids in the neighbourhood.
2. *Non-volcanic (sedimentary) regions:*
 a. *Regions rich in organic sediments (such as peat, coal and oil deposits) or rich in marshes:*

 In areas with oil deposits near the surface of the earth (oil seapages) different hydrocarbons (mainly C_nH_{2n+2}) can be found, though

normally only methane (CH_4) occurs. The earth gases in oil regions contain 80-100% methane. Small quantities of ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}), pentane (C_5H_{12}), hexane (C_6H_{14}) and heptane (C_7H_{16}) occur. CO_2 (0-30%), N_2 (less than 1%), O_2 (0-0.2%), H_2S and traces of olefines (C_nH_{2n}), CO and H_2 have also been found. In certain areas (e.g., Dexter in Kansas) up to 97% N_2 occurs in the earth gases.

Helium, with traces of neon and argon, occurs in certain oil regions (in Kansas up to 2%). High content of helium seems to coincide with high nitrogen values.

Dry oil gases are almost completely composed of methane with only traces of ethane, proane and butane. *Wet gases* contain larger quantities of pentane, hexane and heptane, which are liquids under normal pressures but, under special temperature and pressure conditions, extrude as gases.

Methane occurs, in most marshy regions; this originates particularly during anaerobic fermentation of carbohydrate material of plants. In the U.S.A. methane is not considered important as a means of discovering oil deposits. In the U.S.S.R. however, SOKOLOV and his students consider a certain ratio of the methane content to that of heavier hydrocarbons as indicative of the presence of oil deposits and a means of evaluating the depth of the accumulations. Disintegration of protein deposits in the soil creates a decarboxylation (COOH) of amino acids, giving CO_2 and H_2O and formation of NH_3.

The presence of bones and acids in marshy country gives rise to development of phosphin (PH_3), according to the reaction $Ca_3P_2 + 6HCl \rightarrow 2PH_3 + 3CaCl_2$. At the same time traces of P_2H are formed whic are transformed into P_2H_4.

The mixture of PH_3 and P_2H_4 is self-igniting and burns into P_2O_5. It explains on clear nights the oft-reported cases of so-called "phantom phenomena" above cemeteries. Self-ignition of PH_3 causes ignition of methane gas in marshes, giving rise to the "wandering lights" which have often been explained as the ghosts of people who lost their lives there.

b. *Regions composed of non-organic, mechanical sediments* (sandstone, sand, clay, marl, etc.). The volatile components are mostly due to the vegetation: crushed plants on a path give strong odours (see p. 104); flowering plants create local areas of strong odours that can be absorbed by a porous soil, particularly during high atmospheric pressure, and which are released again during decreasing atmospheric pressure or rising temperature; burrowed moist soil, soil bacteria, certain toadstools, etc., are responsible for volatile components in and just above a porous soil. We have seen on p. 104 that vegetation on soil furthers the absorption of odours, whereas strong wind and rainfall are unfavourable factors.

B. Methods used for measuring soil emanations

In order to determine the presence of oil deposits at great depths several geochemical methods have been worked out; very good results have often been obtained. These methods were based on the fact that hydrocarbons and related constituents of an oil or gas deposit flow continuously, although at a very minute rate, from the reservoir through the overlying strata into the atmosphere. Two different geophysical methods are used: gas and soil analysis.

1. *Gas analysis:* the air in the soil is collected and analysed according to the method of LAUBMEYER (1929), which uses artificial shallow bore-holes, or to the Russian method of V. A. SOKOLOV (1932), using holes of 10-30 ft, dug by means of a hand auger; the shoulder of the hole is wetted, tamped, coated with clay and sealed from the atmosphere by means of a bell-shaped sampling collector. The gases are pumped out with a vacuum pump.

2. *Soil analysis:* samples of the soil are taken at depths from 1 cm to 3 m and the adsorbed gaseous constituents volatilized and analysed, whereas the non-diagnostic constituents (water, CO_2, NH_3, etc.) are removed. The solid and liquid hydrocarbons are removed by selective extraction methods, heating, dry distillation, etc., and are analysed with the use of spectographs and other micro-chemical methods.

The difficulty in the interpretation of geochemical data lies in the fact that the relative and total amounts of hydrocarbons discoverable in any locality depend not only on the texture and structure of the soil but also on the methods of sampling and analysis. Meteorological factors (see p. 238) might considerably influence the results of gas analysis.

Another handicap of this geophysical method is the expense. We mentioned on p. 206 that according to JAKOSKY a geochemical survey may cost $ 3,000-6,000 a month. The cost per sample of an analysis for hydrogen, methane, ethane and hexane was abt. $ 7.50 in the U.S.A. in 1940 and is now considerably more. An analysis of liquid hydrocarbons costs as much as 10 dollars. This makes the claims of certain dowsers even more interesting. On p. 329 we discuss this particular sensitivity of certain dowsers. If this dowsing method can be worked out more scientifically it might prove to be a cheap and useful method in practical geological field work.

This short summary of the geophysical field and the methods of measuring those fields may suffice to appreciate the discussions in chapter III on dowsing. In the following pages a brief survey is given of the third important electro-magnetic field on earth — the meteorological field. This will complete chapter I (in which we have endeavoured to give a review of the electro-magnetic fields in and around living organisms).

PART III: CLIMATOLOGICAL OR METEOROLOGICAL FIELD

(see Bibl. No. 613-619)

Franklin compared the insulating atmosphere to an "infinite ocean of jelly in which in various parts a liquid is entrapped and entangled. These liquids will remain fast bound there until the walls of the jelly which imprison it in some way yield or are ruptured, the liquids being the electric charges in the atmosphere and the organic bodies living in that atmosphere."

Composition of the atmosphere:

The atmosphere is made up of a mechanical mixture of *nitrogen* (78.09%), *oxygen* (20.95%), *argon* (0.93%), *carbon dioxide* (0.03%), *neon* (0.0018%), *helium* (0.0005%), *krypton* (0.0001%), *hydrogen* (0.00005%), *xenon* ($8 \cdot 10^{-6}$%), *ozone* ($1 \cdot 10^{-6}$%), *radon* (i.e., radium emanation, $6 \cdot 10^{-18}$%). These percentages are practically the same throughout the troposphere (see later), except in the case of ozone O_3, the amount of which usually increases with height, while in the case of *radon* the amount decreases with the height. Ozone is mainly concentrated in a layer 20-40 km above the earth's surface; its meteorological importance is indicated on p. 70. The atmosphere also contains water vapour, which is one of the most important meteorological factors, not only because of the transport of water but also because of its capacity to absorb infrared rays (see p. 70). The total amount of water vapour which the air can hold, if saturated, amounts to 35 mm rain in summer (in England) and 15 mm rain in winter (if it is all precipitated).

Structure of the atmosphere:

It is mainly composed of two layers, the lower, *the troposphere* and the upper, *the stratosphere.*

In the *troposphere* the temperature decreases upwards abt. 5.6° C/1000 m up to a certain point, the boundary of troposphere and stratosphere. From that point upwards the temperature remains rather constant. This boundary lies at 18 km height at the equator (temperature —85° C), at medium latitude at 10-11 km height (temp. —55° C), in polar regions at 8-10 km (temp. —53° C). The atmospheric pressure also decreases upwards, the decrease being first abt. 1 mm pressure/10 m, but gradually becoming less. At 6000 m height the atmospheric pressure is abt. 380 mm, i.e., half the normal pressure at sea level.

Only in the troposphere do the irregular meteorological conditions exist. Both water vapour and carbon dioxide act as main heat regulators of the troposphere as they allow sun radiation to pass, but they absorb or reflect downwards the heat radiation of the surface of the earth.

The stratosphere is divided by J. Hann a.o. into a lower heavy part, relatively rich in nitrogen, and a very light upper part, rich in hydrogen. The boundary between *nitrogen* and *hydrogen sphere* has been taken

at abt. 70 km height as the famous ash clouds of the Krakatau eruption in 1883 and the echos of heavy explosions (e.g., in 1908) occurred at that level. It is near this boundary (at 80 km) that a higher electric conducting layer occurs (see later) known as *Heaviside layer*, the atmosphere above this horizon being called *ionosphere*.

1. Causes of the electric field of the atmosphere

A. Kind of ions in the atmosphere

The electric field of the atmosphere shows up in the conductivity of the air; this results from the presence of charged particles, known as ions. Two kinds of ions are distinguished:

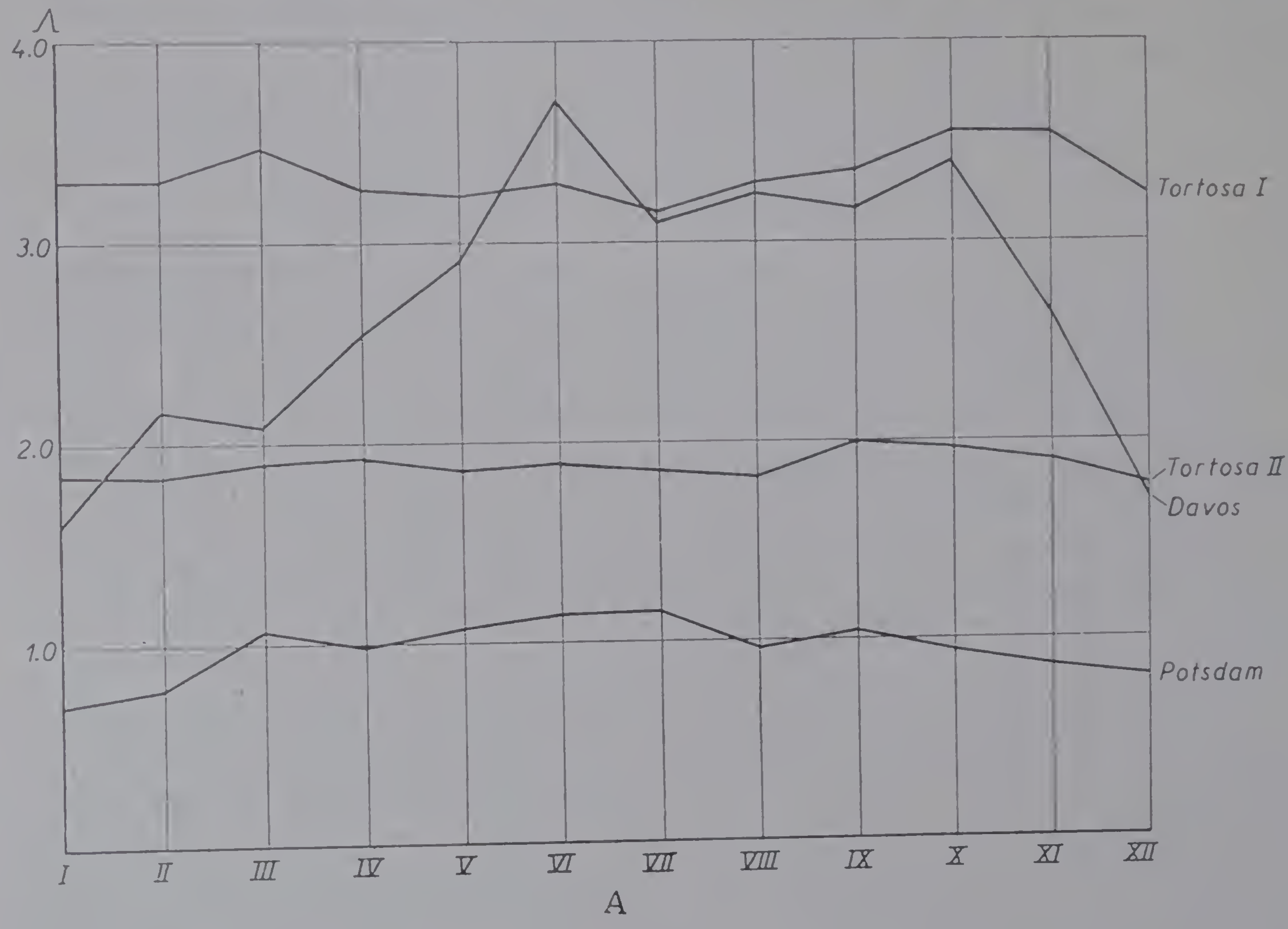
1. *Small ions* composed of electrically charged clusters of molecules of atmospheric gases, with great mobility (1 cm/sec in an electric field of 1 V/cm) and an electric charge per ion of $15.9 \cdot 10^{-20}$ Coulomb. There are on the average 500-600 small ions of each sign in a cm^3 of air (number of ordinary molecules in 1 cm^3 dry air at 0° C and 76 cm pressure $= 2.75 \cdot 10^{19}$ molecules).

2. Langevin *ions* are sluggish ions with charges attached to Aitken *nuclei*, the hygroscopic particles on which moisture condenses when clouds are formed. They are considerably less mobile (average velocity 0.0005 cm/sec) than the small ions. In places where the atmosphere is polluted by dust and products of combustion of coal, Aitken nuclei are more frequent than small ions. Values of 50,000 and more Langevin ions/cm^3 are common near towns. The atmosphere contains positive and negative ions, but the observation that in general the potential gradient (see further) falls off as we ascend in the atmosphere (indicating that the net charge of the air is positive) implies that there must be an excess of positive ions.

Variations in conductivity of the air are explained by the different proportions of large and small ions, differences in speed and presence of conductors.

1. If large ions are formed (e.g., in strongly polluted atmosphere) at the expense of small ions, the effective conductivity is reduced because of the smaller mobility of the Langevin ions and the air-earth current (see further) is maintained by a higher potential gradient.
2. Negative ions diffuse with greater speed than positive ions.
3. The ratio between both velocities decreases in humid air (in dry air abt. 1.54, in humid air 1.09); it increases with decreasing atmospheric pressure (according to Townsend, 1899) and increases with rising temperature (according to Mc Clelland).
4. The general mobility of negative ions is usually greater than that of positive ions. A ratio of 1:100 has been found in certain gases.
5. According to Leiri (Bibl. No. 641), ionizing sources (e.g., an electric tension of 190 V/cm) create 57 times more negative than positive ions (see also p. 81).
6. Janitzky (Bibl. No. 637) could demonstrate the influence of metal conductors:
   a. air brushing past a metal surface through a pipe is positively charged;
   b. the surplus in positive ions increases if the metal surface is heated;
   c. the surplus decreases if the metal surface is lacquered.

As a result, in the neighbourhood of an iron stove or central heating pipes, the air is rich in positive ions according to TCHYEVSKY (Bibl. No. 652). The increase in charge is caused by differences in rate of absorption of ions by metal surfaces. Air passing through insulated pipes absorbed up to 30% of the ions of the air.



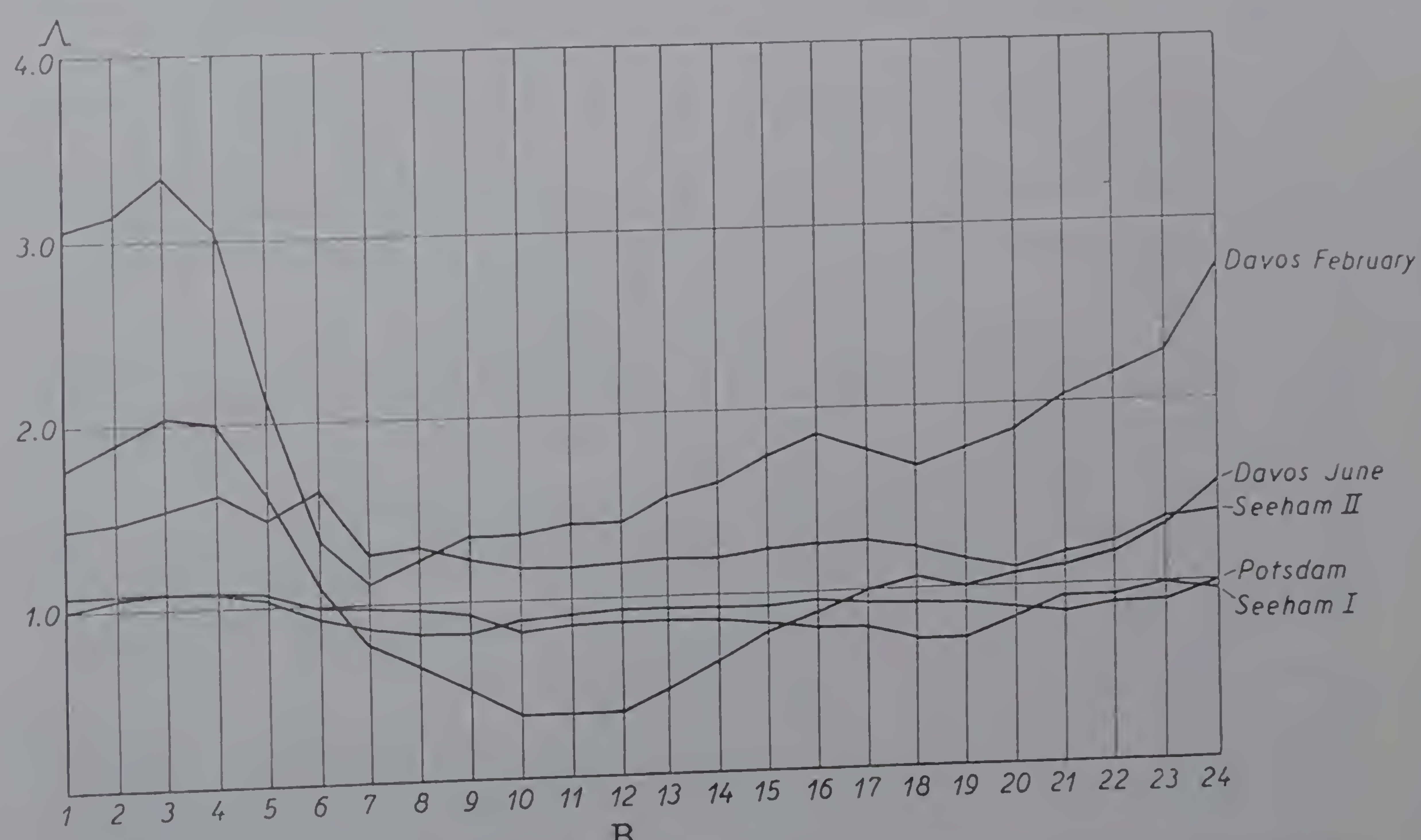


Fig. 68: (Bibl. No. 606, p. 745) Conductivity of the atmosphere at different localities. A = yearly variations of conductivity; B = daily variations.

Since free ions of opposite sign tend to recombine and give up their charges, there must be active causes of ionization at work. The rate of recombining is greatly influenced by the different factors, mentioned above, which influence the velocity of ionic movements (see also p. 61, influence of electric fields on ionic movements; p. 81, influence of magnetic fields).

The total effect of the different processes mentioned above, determines the final conductivity of the atmosphere which also varies as a result of different cosmic influences discussed on p. 250. Fig. 68 shows graphically the conductivity of the atmosphere at different localities. Fig. 69 indicates the *electric charge of the atmosphere* during different hours of the day, which could be determined, for example, by passing a certain volume of air through a cylindric condenser with a strong electro-static field. The charging of an internal electrode, depending on the direction of the electro-static field, indicates the positive or negative ionic charge of the air. The difference between both ionic charges gives the actual atmospheric charge. According to OBOLENSKY the average yearly charge at Leningrad amounts to $33 \cdot 10^{-10}$ C/cm³.

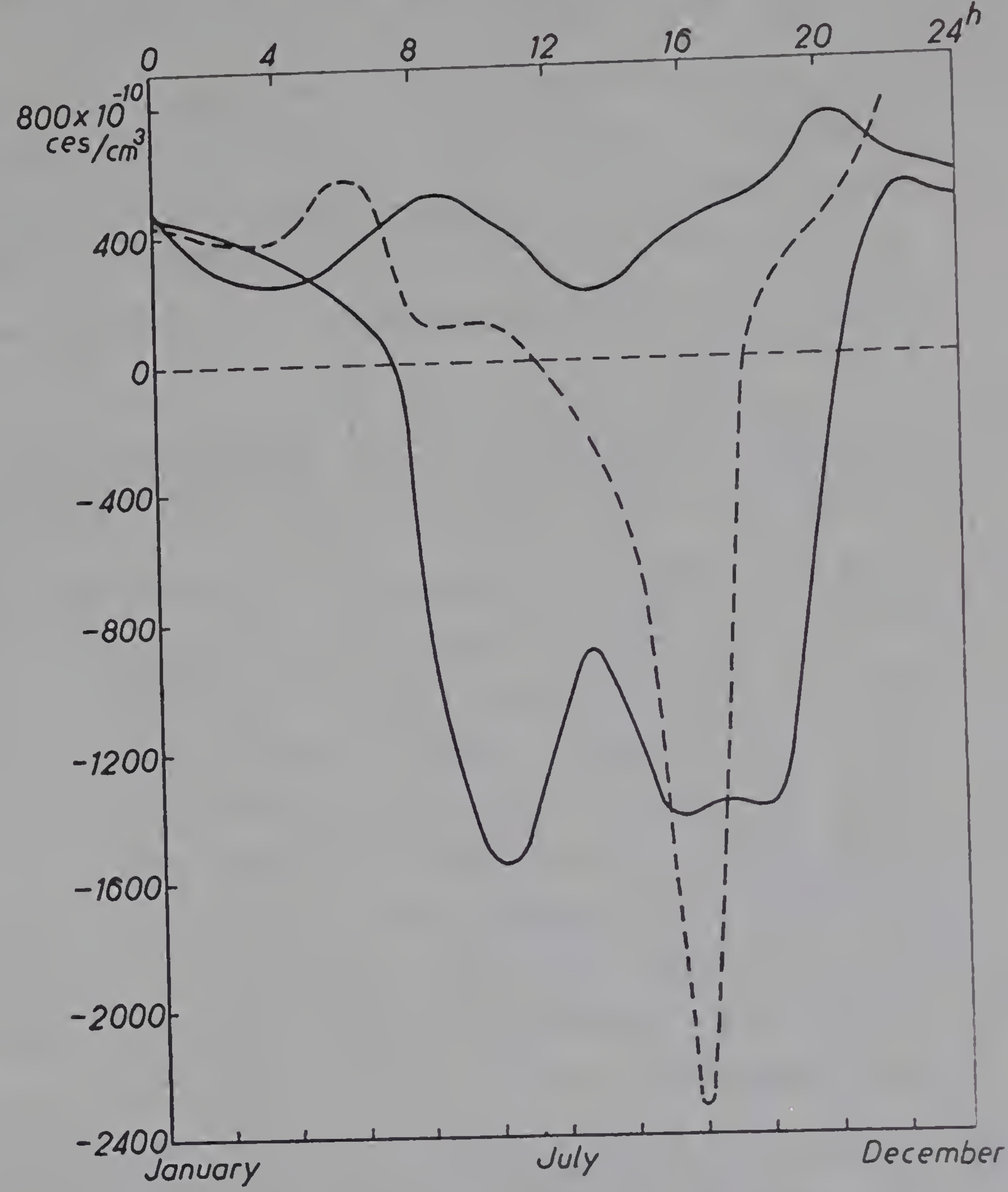


Fig. 69: (Bibl. No. 606, p. 780) Electric charge of the atmosphere at Leningrad (after OBOLENSKY). Dotted line indicates yearly fluctuations; solid lines daily fluctuation, the upper one for the month of January, the lower for August. Curves indicate large negative charges in summer.

B. CAUSES OF CONTINUOUS IONIZATION

We mentioned on page 64 the mechanism of ionization and the different electro-magnetic sources which are able to ionize. It will be sufficient, therefore, to mention briefly the main sources of electric charges in the atmosphere:

1. *Cosmic radiation:* see p. 63 and 284;
2. *Radioactive emanation:* see p. 63 and p. 238;

3. *Corpuscular sunradiation:* see p. 63; particularly active during periods of great sun activity; according to CHAPMAN a.o., corpuscular rays are composed of particles with a velocity of $2 \cdot 10^9$ cm/sec penetrating in the atmosphere only to a height of 80 km.

4. *Ultraviolet sun radiation:* see p. 66; at great height in the atmosphere, ultraviolet waves with wavelength smaller than 0.2 μ seem to be important as an ionizing source. As waves smaller than 0.29 μ do not penetrate the atmosphere below 9 km height, the ultraviolet rays are of no importance as ionizing factor for the lower parts of the atmosphere.

5. *Friction between mineral fragments:* in dust storms, particularly in desert regions (see also p. 177, electric charges of minerals).

6. *Friction electricity between ice crystals in snow,* the RUDGE *effect:* due to the piëzo-electric phenomena of crystals (see p. 16). Friction of ice crystals creates electrostatic charges. KÄHLER and STÄGER could demonstrate that whirling up of snow creates considerable electric charges. The charges on snow are usually of the order of magnitude of $20 \cdot 10^{-9}$ coulomb/cm³, although values of up to $205 \cdot 10^{-9}$ coulomb/cm³ have been reported from single snow-flakes. The charges are either positive or negative and greatly exceed the charge of raindrops (see below). During snowfall mostly high positive and negative potential gradients have been reported (see below)

7. LENARD *waterfall effect:* LENARD discovered about 1915 that sudden breaking up of large drops of water is accompanied by the formation of tiny electro-negatively charged droplets. Water drops of 2.5 mm diameter floating in the air can be disintegrated by an air current of 20 M/sec; drops of 5.5 mm require currents of 10.9 M/sec. The principal cause of electrification of rain is probably this breaking up of the drops. The diameter of raindrops near the surface of the earth is generally less than 2 mm, but during thunderstorms drops of up to 5 mm have been recorded. When the velocity at which a raindrop falls through the air exceeds a certain limit, it is broken up into a number of small droplets which become positively charged in the process. The corresponding negative charges are carried away by the finer spray or by air currents. Powerful ascending currents in thunderclouds (with vertical velocity greater than 8 M/sec) are particularly capable of carrying the drops upwards, breaking them up into droplets. It has been found that though both positive and negative raindrops occur, the positive ones predominate. The charge per cubic centimetre of rain is generally less than $1/3 \cdot 10^{-9}$ C, although in a few cases charges of up to $20 \cdot 10^{-9}$ coulomb have been observed.
   Differences have been noted between so-called *land-rain* and *thunderstorm-rain.*

a. During land-rain 75% of the rain is positive; the potential gradient in the atmosphere (see below) is mostly negative.
b. The positive rains dominate during thunderstorms. The electric charge per gram of rain is considerably larger than that of land-rain. The potential gradients fluctuate between high positive and negative values, the negative ones dominating.

C. Causes of the air-earth current

1. C. 1. Conductivity of the air at appreciable height

It has been found that the conductivity of the atmosphere increases with the height. WIGAND demonstrated that at 3 km height the conductivity increased to 5 times, at 6 km to 10 times, at 9 km to 26 times the ground value. According to GISH and SHERMAN the increase at 18 km height is 100 times the ground value. This increase is partly due to enlarged ionization, but it is mainly caused by the increased mobility of the ions (because of decreased atmospheric density). At a height of 70-100 km (near the boundary of the nitrogen-hydrogen spheres, see above) very great values were observed. According to BENNDORF (1926) the conductivity due to cosmic radiation amounts to 10^4 sec^{-1} at 60 km height and 10^6 sec^{-1} at 80 km height; according to ELIAS (1926) the corpuscular sun radiation would create a conductivity of 10^8 sec^{-1} at 80 km height. This highly conductive horizon at a level of 80 km is called KENELLY-HEAVISIDE *layer*, the maximum ionization occurring at 100 km height; it is responsible for the reflection of the radio waves on earth. APPLETON could prove that there is another conducting region above the HEAVISIDE layer at abt. 180 km height. It is known as the APPLETON *layer*. The part of the atmosphere above 80 km height is called the *ionosphere*. It is only in this upper part of the atmosphere that *polar light* phenomena occur (see below).

1. C. 2. Potential gradient in the atmosphere

FRANKLIN discovered that a wire attached to a kite flying at a considerable height, even in fine weather, becomes electrified and sparks may be drawn from the wire. This proves that there is a large difference of potential between the ground and the air at the level of the kite. It is found that in the open the potential changes fairly uniformly with height. This rate of change is called *potential gradient* of the atmosphere. In fine weather near the ground it is of the order of 120-150 V per metre, the higher potential being at the greater height; the potential gradient is called *positive* in this case.

Going up from the earth the potential goes on mounting and at the levels attained by aircraft it may reach hundreds of thousands of volts. The potential gradient however diminishes as we go upwards. At 9 km

height it is only a few volt/meter. The potential gradient fluctuates continuously both in the horizontal and vertical direction. The different causes of the variations are discussed later on.

1. C. 3. Earthcharge

The existence of a positive potential gradient indicates the presence of a negative charge on the ground which is compensated by the positive charge of a layer of air of abt. 9 km high. With a gradient of 100 V/m prevailing over the whole globe, the total charge of the earth would be $4.5 \cdot 10^5$ coulombs, i.e., $9 \cdot 10^{-14}$ C per cm^2. This total charge of the earth is very small and can supply a current of only one ampère for five days. As the gradient varies considerably and large areas might also have negative gradients the value $4.5 \cdot 10^5$ C is only a very rough approximation. All in all, the earth with the atmosphere can be considered as a *spherical condenser* composed of a relatively well conducting negatively charged *earth crust*, a poorly conducting positively charged *air layer* of 80 km thickness and a very good conducting *ionosphere*.

1. C. 4. Air-earth current

The electric field of the atmosphere and the negatively charged earth crust together create an air-earth current which is continuously neutralizing the negative earth charge with the positive charge of the atmosphere. This current can be measured by substituting a metal plate for part of the ground. This current is abt. $8 \cdot 10^{-7}$ ampere/cm²/sec (according to other estimates $2 \cdot 10^{-6}$ ampere/km²), giving a total current toward the whole earth of 1400 ampère. Small as this current is, it suffices to neutralize the fine-weather charge on the ground in a fraction of an hour. There is at certain places a negative potential gradient and therefore a reverse current. Rain, snow and lightning might bring also negative charges to the ground, but this alone can hardly explain the preservation of electric balance.

D. Causes of preservation of balance between positive and negative flow

Different theories have been put forward to explain this extraordinary phenomenon, but none have succeeded in giving a completely satisfactory explanation.

a. *Reverse current theory of* C. T. R. Wilson (1925): measurements by G. C. Simpson and F. J. Scrase (1927) with an alti-electrograph demonstrated that the upper part of cumulo-nimbus clouds practically always has a positive charge, the base being negative. This is explained by Simpson (1909) as caused by the vigorous upward currents in cumulonimbus clouds, which break up the large raindrops (see above) and create droplets with positive charge. These accumulate at the upper end of the cloud. The smaller negative droplets escape sidewards and accumulate at

the base of the cloud. If the electric charges at the different parts of the clouds are sufficiently great, a flash of lightning occurs, the quantity of electricity discharged being of the order of 20 coulombs (acc. to C.T.R. WILSON, 1920). The lightning consists of several partial discharges with intervals of 0.37 sec. (acc. to MATTHIAS), the sign of the electricity brought down to the earth by a lightning stroke being mostly negative. WILSON pointed also out that the negative base of these nimbus clouds induces a positive charge on the surface of the earth which, as a direct result, repulses the positive ions of the atmosphere. Fluctuations of the potential gradient, parallel with thunderstorms, support this theory.

b. *Electron-current theory of* E. v. SCHWEIDLER (1918) and W. G. F. SWANN (1917): SCHWEIDLER and SWANN assumed that a stream of electrons reached the surface of the earth either as a corpuscular radiation from the sun or as a secondary β radiation created by cosmic rays. Supporters of this theory pointed to the relation between *Northern Lights phenomena* (acc. to STÖRMER, BIRKLAND a.o., resulting from the deviation of the electron radiation of the sun by the magnetic field of the earth) and fluctuations of the potential gradient.

c. RUDGE *effect:* the temperatures at the top of cumulo-nimbus clouds might be well below the freezing point of water. It has been assumed, therefore, that the high negative potential gradients, which have been noticed during snowfall, are due to the friction of snow crystals and the creation of negative charges which are carried downwards.

2. Causes of variations of the atmospheric electricity

The variations of the electric field of the atmosphere show up clearly in the fluctuations of the potential gradient, which normally has a positive value everywhere on earth. A short summary of the causes of these fluctuations is required in order to understand some of the dowsing phenomena discussed in chapter III.

A. INFLUENCE OF THE TOPOGRAPHY OF THE EARTH SURFACE:

In fig. 70 a diagram shows the changes in form of the lines of equal potential gradient in the atmosphere, indicating the influence of houses, trees, etc.

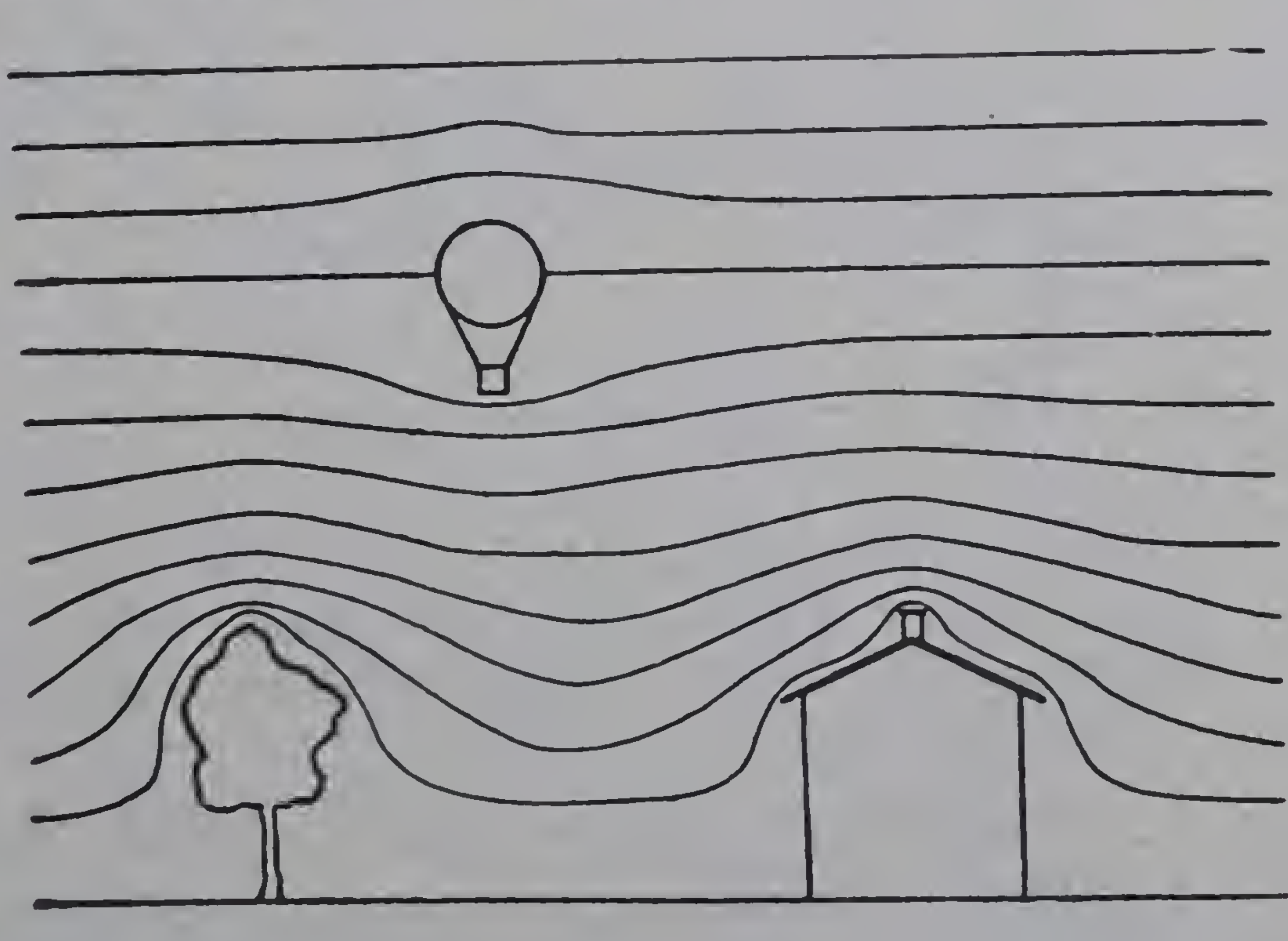


Fig. 70: (Bibl. No. 606, p. 768) Equipotential lines in the atmosphere in the neighbourhood of the earth surface, indicating the influence of houses, trees, etc.

B. Influence of weather conditions

The potential gradients depend to a great extent on the condition of the atmosphere:

1. If the air is clear, the gradient is low, higher when there is haze and very high when fog prevails (values of 2,000 V/m have been recorded).
2. During land-rain the gradient is mostly negative; throughout thunderstorms it fluctuates enormously between high positive and negative values, the latter being dominant. Values of 10,000 V/m have been recorded.
3. During snow-fall, high positive and negative potential gradients occur.
4. The potential gradient above the sea (similar to clear air) is low (115-140 V/m); near cities or industrial centres it is high.

C. Influence of the distribution of the equipotential lines at the surface of the earth: (see p. 227 and 233)

D. Cosmic influences

1. *Daily fluctuations:* the potential gradient shows a diurnal variation similar to the daily variation of the magnetic field. In figs. 68 and 69 we give two diagrams showing the daily fluctuations of the conductivity and electric charges of the atmosphere. Fig. 71 shows daily fluctuations above the sea; figs. 72 and 73 give graphic representations of the diurnal variations on land.

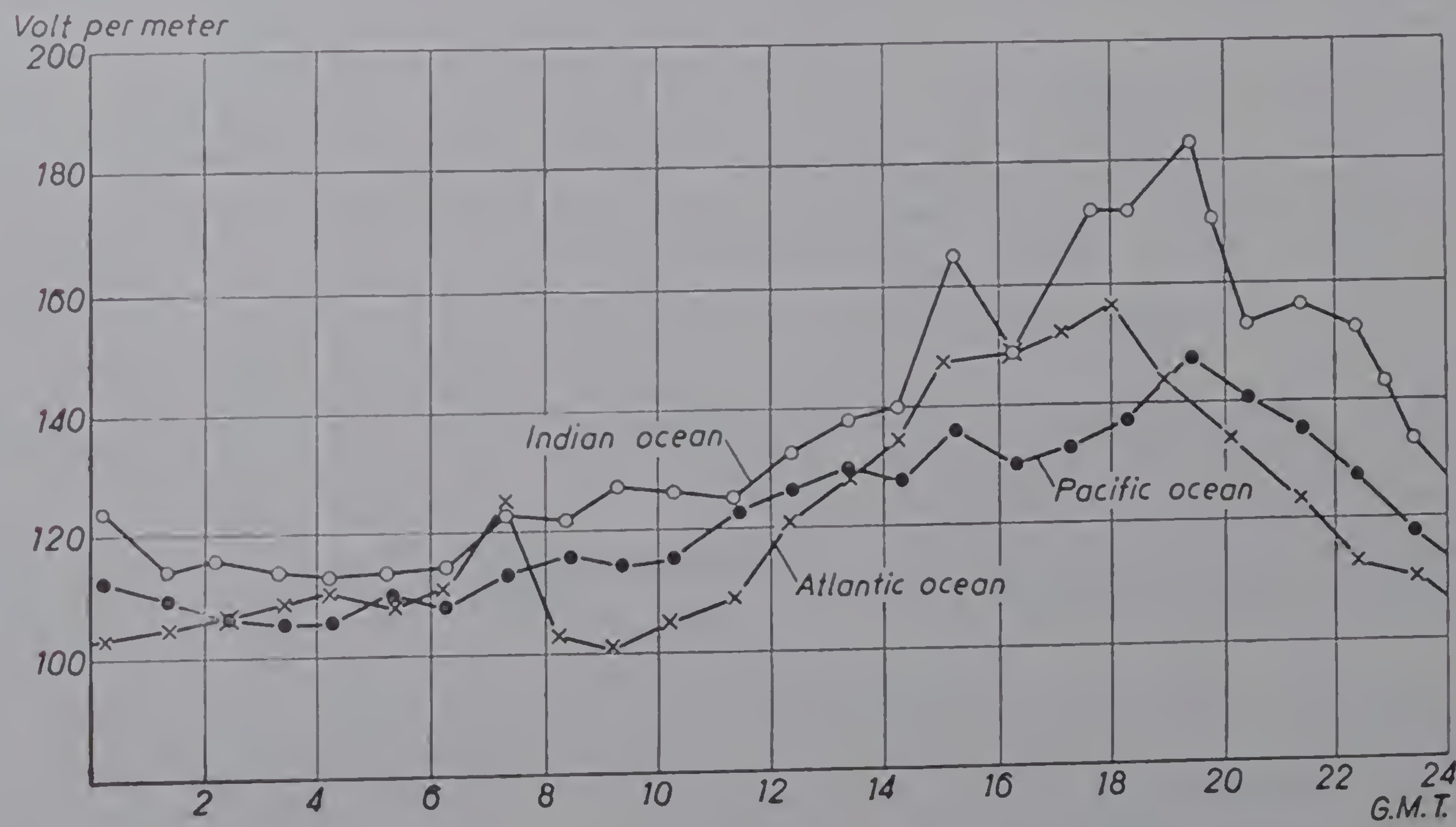


Fig. 71: (Bibl. No. 606, p. 772) Average daily fluctuations of the potential gradient in the atmosphere above the sea. White circles, Indian Ocean; blach spots, Pacific Ocean; crosses, Atlantic Ocean.

a. Mauchly discovered in 1926 that over the *ocean* and in *polar regions* the diurnal variations of potential gradient are governed by

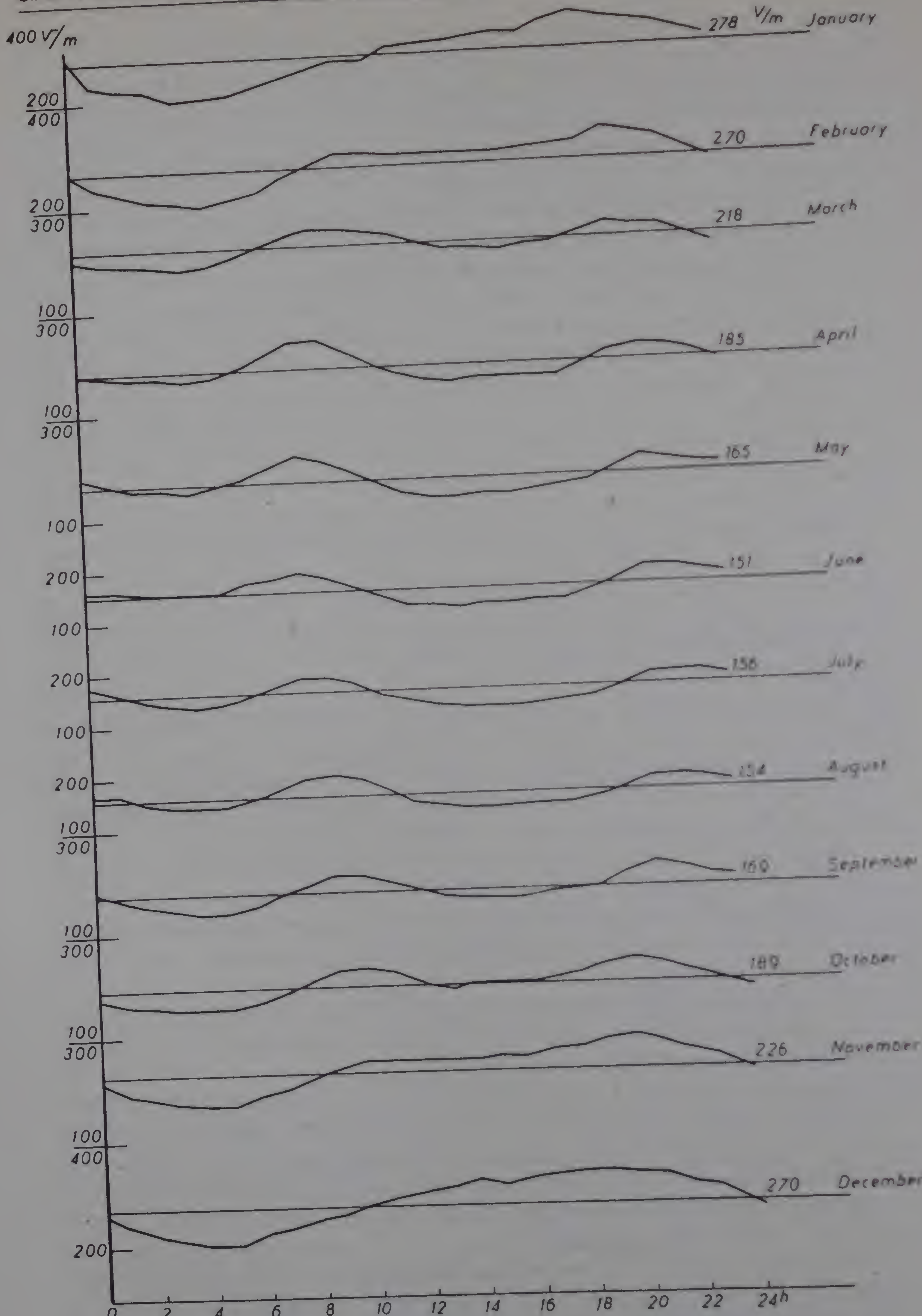


Fig. 72: (Bibl. No. 606, p. 775) Average daily fluctuations (over a period of 20 years) of the potential gradient in the atmosphere at Potsdam (Germany) during the different months of the year.

world-time, the minimum (107 V/m) occurring at 4 h Gr.M.T., the maximum (150 V/m) at 19 h Gr.M.T., the average gradient being greatest from October-March, smallest from April-September. The time of the maximal gradient (17 h Gr.M.T.) is remarkable, as it is the moment that the sun passes the meridian of the magnetic northpole (discovery of SIMPSON).

b. Studies at 20 *continental stations* indicated fluctuations of the daily amplitude of the potential gradient on land of 16 to 145 V/m. Two main types of daily fluctuations seem to occur: the first shows a *simple oscillation* with a minimum at 4 h and a maximum between 18 and 20 h; the second type shows a *double oscillation* with a maximum at 8 and 20 h and a minimum at 4 h and round 14 h. Transitional types occur between both curves as indicated in fig. 72. In the northern hemisphere the simple oscillation type usually occurs in winter only; in summer the double oscillation dominates.

In Kew and a few other places a double curve was obtained during winter. It was found later that this was due to the *electrode effect*, which is caused by a great concentration of negative ions near the topographic surface of the earth and of positive ions at a certain distance from it. If the potential gradients are measured by placing the collector at a distance of 35 cm of a house, a double curve is obtained in winter, at a distance of 170 cm the simple curve generally appears.

2. *Yearly fluctuations:* an average of 20 stations on land indicated fluctuations of the average yearly amplitude of 20 to 239 V/m. Stations north of 30° N and S of 40° S show a pronounced yearly oscillation of the daily fluctuations with a maximum between November and January and a slight minimum between July and August; of the stations between 30° N and 40° S only the most northerly and southerly ones show a pronounced oscillation, with a maximum in July-August and a slight minimum between November and March. Irregular fluctuations around an average value occur near the equator.

   Yearly fluctuations (see figs. 68 and 69) are shown, not only by the potential gradient, but also by the conductivity and electric charge in the atmosphere.

3. *Eleven-year period:* L. A. BAUER (1924) could demonstrate a close relation between the number of sunspots and the potential gradient; the latter increases 20% with a 100% increase in the number of sunspots; the daily and yearly amplitudes of the potential gradient also fluctuate parallel to the curve of sun activity and seem to be related to the north light phenomena.

The deeper causes of these cosmic influences are only partly known. Variations in ionizing power of cosmic sources (corpuscular, ultraviolet and cosmic radiation) and periodical changes in meteorological conditions (atmospheric pressure, temperature, humidity) are probably mainly

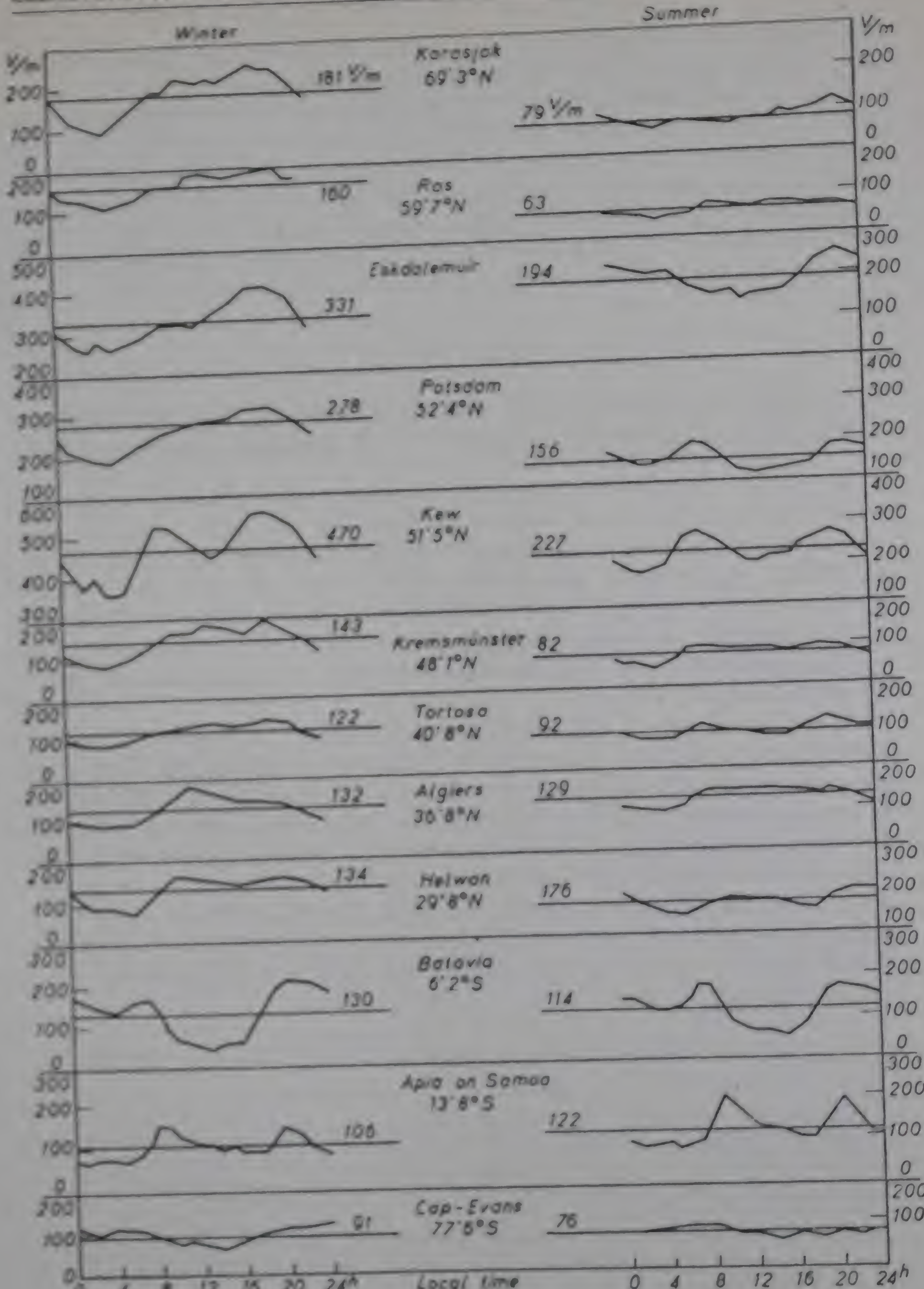


Fig. 73: (Bibl. No. 606, p. 776) Average daily fluctuations of potential gradient in the atmosphere during winter (left column) and summer (right column), at localities with different latitude.

responsible for periodical or secular variations of the conductivity of the atmosphere and of the potential gradient.

The great influence of the meteorological field on living organisms, which is discussed more in detail in chapter II, part II (influence of atmospheric ionic currents), indicates that in future considerably more research work needs to be carried out on the deeper causes of these fluctuations which influence either directly or indirectly many of the activities of man. It is for this reason too that divining phenomena cannot be studied without taking this factor into consideration.

CHAPTER II

FURTHER EVIDENCE OF THE INFLUENCE OF EXTERNAL ELECTRO-MAGNETIC FIELDS ON LIVING ORGANISMS

In chapter I we demonstrated the continuous interaction between the organic, geophysical and meteorological fields on earth. Further evidence of the influence of external electro-magnetic fields on living organisms might seem superfluous. Nonetheless we include a special chapter on this subject as we found that a great number of biological experiments which *directly* indicate this influence are unknown to most natural scientists. This chapter also gives further support to our statements in chapter III.

There are 5 parts: part I discusses the *influence of external electrostatic fields* in general; part II the *influence of atmospheric ionic currents;* part III the *influence of magnetic fields;* part IV the *influence of electro-magnetic radiation;* in part V a summary is given of the different geological and geophysical factors that influence living organisms on earth, both in the past and present. Although not directly belonging to the group of externally stimulating electro-magnetic forces the *influence of supersonic waves* on living organisms should also be included. These phenomena, however, are discussed on p. 109 and 110 and are therefore omitted.

PART I: INFLUENCE OF ELECTROSTATIC FIELDS
(see Bibl. No. 620-629)

The influence of electric fields on living organisms depends on the kind of electric field applied. These electro-biologic phenomena have been classified by SCHEMINZKY (Bibl. No. 6) as follows:

1. *Electro-taxis:* directed autonomous movements of freely moving plants or animals in electric fields; direct relationship between movement and lines of force is not required
   a. *Galvano-taxis:* movements due to direct current
   b. *Oscillo-taxis* (SCHEMINZKY, 1926): due to low frequency alternating currents

2. *Electro-tropism:* directed development of plants or animals due to electric fields; a relationship always exists between the direction of development and the lines of force
   a. *Galvano-tropism* (HERMANN, 1885 and VERWORN, 1889): due to direct currents; common in more highly developed plants
   b. *Plerosi-tropism* (AMLONG, 1934): due to constant electrostatic fields
   c. *Oscillo-tropism* (SCHEMINZKY, 1926): due to low-frequency alternating currents
   d. *Hertzo-tropism* (HEGLER, 1891): due to electric vibrations

Only plerosi-tropism phenomena are touched upon as they are less known than any of the other electro-biologic phenomena.

The influence of electrostatic fields can be direct or indirect. The indirect influences, due to the action of atmospheric ionic currents, are discussed in part II of this chapter. A few other phenomena are reviewed in this part. The effect of electrostatic fields on living organisms has been studied both in plants and animals (and man).

1. Influence of electrostatic fields on animals and man

Different experiments indicate this influence:

A. On p. 182-183 we dealt with the succesful medical treatment of the human body with electrostatic fields under certain conditions of illness.

B. On p. 122 we mentioned the experiments of GENGERELLI and HOLTER with nerves (see also Bibl. No. 383).

C. *Cancer experiments of* F. VLÈS *and* A. DE COULON (Bibl. No. 623-629).

1. A series of experiments were carried out in 1930 by VLÈS in Straszbourg and DE COULON in Lausanne with 53 geranium plants in pots, of which 26 were earthed and 27 were placed on an insulated board. After two months they were grafted with Bacterium tumefaciens, which normally causes cancer phenomena in plants. After a further two months 10 of the 53 plants showed a tumour development, of which 8 belonged to the earthed flower pots.
2. A similar experiment was carried out with 50 mice placed in 6 earthed and 6 insulated wooden cages with metal bottom. Each group of 6 cages was placed on wooden boards suspended on ropes impregnated with paraffin. Cancer was developed on the skin of the mice by means of tar. After 172 days 16 of the 25 earthed mice were still alive of which 15 had a tumour (i.e., 94%). Of the 14 remaining insulated mice only 9 had a tumour (i.e., 64%).
3. In 1931 the experiments were repeated with 800 mice treated with tar and 1,200 control animals. The experiment lasted 250 days. According to VLÈS and COULON the earthed mice took carcinoma on an average of 60 days earlier than the insulated mice.
4. The experiment was repeated from January 1931 till January 1932 with 10,000 control-mice, 700 earthed mice and 600 insulated mice. The earthed cage was connected with one of the poles of a 2-volt

accumulator, the other pole being earthed. Of the earthed mice 26 developed a tumour, of the insulated animals only two. 6 of the earthed mice with a tumour were afterwards placed in an insulated cage with the result that in 5 of the 6 cases the tumour disappeared (histologic determinations were made by Prof. NICOD at Lausanne).

5. The experiments were continued in 1932. On July 23rd, 1932, of 1,300 earthed mice 38 developed a carcinoma (i.e., 2.9%); of 600 insulated mice 8 (i.e., 1.3%). All 46 cases of carcinoma developed only in female mice.
6. The experiments of VLÈS and COULON were repeated by Prof. H. T. DEELMAN, director of the Pathological-Anatomical Laboratory at Groningen (Holland) and his assistant H. L. VAN VIERSSEN TRIP (see Bibl. No. 623) with 250 white mice placed in wooden cages with 24 compartments (6 rows of four above each other), the surface of each compartment measuring 17×34 cm. 4 mice were kept in each compartment. The roof of the compartment was covered with zinc. All zinc plates were connected with copper wire. The walls were covered with glass. The cage with 24 compartments (96 mice) was suspended on dried ropes and impregnated with paraffin and porcelain insulators. Three cages were prepared; one was connected to the earth; the second was earthed with a 12-volt battery; the third was insulated; all three were suspended on a large roof attic with sufficient indirect sunlight. Temperature and humidity were constant in all three cages. After 200 days both scientists came to the conclusion that all three curves were practically coincident and that neither static electricity nor earthing has any effect on tar carcinoma. This hasty conclusion is a typical example of the attitude of a great number of scientists if extremely subtle and rather unusual phenomena are reported by other scientists, even by those as prominent as VLÈS and COULON (the integrity of their research methods is respected by DEELMAN and VAN VIERSSEN TRIP). It is this same attitude which we encountered during the discussion of the GURWITSCH radiation (see p. 19-25). DEELMAN decided to "repeat" the experiments of VLÈS and COULON, but the following striking differences can be reported:

a. DEELMAN and v. VIERSSEN TRIP did not seem to appreciate the fact that if the results of VLÈS and COULON were trustworthy one of the reasons of this influence could have been that the influence of the potential gradient was different in both cases (see e.g., electrode effect, p. 252). The potential gradient itself and its fluctuations are completely different in Groningen and Switzerland (see p. 252), apart from temperature, atmospheric pressure and humidity. It is quite possible that the phenomena observed by VLÈS are bound to certain potential gradients, because, as is well known in all electro-biologic phenomena, certain stimulations might further the development of an organism until a certain optimum is reached, while prolonged stimulation might have the reverse effect.
b. VLÈS used wooden cages with a "metal bottom" whereas DEELMAN used glass-covered cages with a "zinc roof."
c. The number of mice in each cage was different from VLÈS' experiment. In the experiment both sexes were united, with VIERSSEN they were separated.

d. By connecting the zinc plates, the mice in each of the compartments above each other were actually placed between two zinc plates of equal potential, whereas in VLÈS' experiment the same potential difference did not exist between the metal bottom in the cage — on which the mice walk — and the surrounding air.
e. VLÈS and COULON in one series of experiments fed each group of 30 mice with the yolk of 4 eggs (in onc a day); this increased the taking oı carcinoma by almost 10%, whereas DEELMAN used bread saturated with milk, vegetables and cheese.
f. The influence of zinc during this experiment was rather uncertain if we consider the phenomena discussed on p. 33-48 (RUSSELL *effect*). The FIGGE *effect*, due to cosmic rays (see p. 287), might also influence the results of this experiment.
g. Neither the tar used, nor the method of application of tar on the skin was the same. On p. 870 (Bibl. No. 623) VAN VIERSSEN TRIP writes "not all mice obtained the same number of tar applications".

We agree that the experiments of VLÈS and COULON are far from conclusive, but on the other hand the conclusions of DEELMAN and VAN VIERSSEN TRIP are very hasty. The only conclusion they are allowed to draw is that no differences in cancer development were observed under the specific conditions of the experiments in Groningen. Their hasty conclusion is the more regrettable as a negative statement by a well-known scientist such as Prof. DEELMAN easily prevents other research workers from repeating the experiments of VLÈS and COULON. However, it is hoped that these important experiments will be repeated by taking into con sideration the pecularities of the potential gradient on earth (see chapter I, part III).

2. Influence of electrostatic fields on plants

A. *Experiments of* A. DE VITA (1933)

MABY (Bibl. No. 621, p. 109) has given an excellent summary of these experiments, which were described originally in Bibl. No. 624. "DE VITA examined the effects of electric fields on plant growth, for which purpose he grew plants in earthenware pots of soil on carefully insulated supports over two electrified metal grids. The latter were also insulated and raised above the ground, being connected to the positive and negative poles of a 150 volt dry battery respectively, with the positive pole earthed. With this arrangement wheat (Triticum vulgare), mustard (Sinapsis alba) and pea (Pisum sp.) plants were investigated. The plants over the negatively charged grid grew most rapidly; plants on a neutral control grid were inferior to those on the negative grid, but superior to those on the earthed positive plate. In case of disease there was less damping off of the negative plants than on either the positive or neutral cultures." These experiments, if they could be confirmed by other scientists, would show that the influence of the potential gradients in the atmosphere plays an important role.

B. *Experiments of* BECQUEREL AND NOLLET

These workers claim that positive electrification of plants hastens germination, while negative charges retard it. This was confirmed by MABY (Bibl. No. 621, p. 110), who found that subsequently growth of the nega-

tive cultures surpassed that of the positive ones, though the latter showed a tendency to earlier flowering and fruiting.

C. *Experiments of* R. JEMMA (1934)

JEMMA (Bibl. No. 620 a) used direct electrification of the soil of pot-plants and found that the growth of the negatively charged plants caught up with and surpassed that of the positive ones after four to six days.

These few experiments, although not conclusive, are sufficiently promising to recommend large scale experiments by biological experimental stations. As in all biological experiments it is extremely difficult to obtain results which can stand the most serious criticism if the calculus of probabilities is applied. Only objective research for many years might reveal the influence of the electro-static field of the atmosphere on living organisms.

PART II: INFLUENCE OF ATMOSPHERIC IONIC CURRENTS

(see Bibl. No. 630-653)

1. Historical review of aero-ionic therapy

In 1899 CASPARI and ASCHKINASI assumed that *mountain-sickness*, which is characterized by headaches, weakness, nausea, vomiting and insomnia, is partly caused by great concentration of aero-ions in cavernous or narrow valleys free of air-currents.

In 1901 CZERMAK explained the *föhn-sickness* in a similar way. These ideas were further developed by A. P. SOKOLOFF and in 1910 resulted in *aero-ionic therapy*, i.e., treatment of certain diseases with aero-ionic currents introduced by STEFFEN.

First large-scale scientific studies on the influence of aero-ionic currents were started in Moscow about 1919 by Prof. A. L. TCHYEVSKY (see Bibl. No. 643-653), later director of the "Central laboratory for Ionic Research", supported by his pupils BOBROV, PEREDELSKY, BABADJANIAN, a.o.

Similar research work was started in Germany in about 1920 by F. DESSAUER in the "Institut für physikalische Grundlagen der Medizin" at Frankfurt. In 1931 the results of 10 years of experiments by DESSAUER and his pupils HAPPEL, ERDSTRÖM, KÜSTER, JANITZKY, WOLODKEWITSCH a.o., were published (see Bibl. No. 631).

A great number of scientists in different countries have continued these studies of which LEIRI (Bibl. No. 638-641) in particular must be mentioned. They discovered that a current of negatively charged aero-ions has specific biologic effects (mostly favourable), though not every human organism appears to be equally sensitive. DESSAUER and LEIRI assumed that the great variability in sensitivity is determined by the different amount of resorbable ions in the air and the varying electric

conditions of the resorbing membranes in the human body. Only ions with dimensions smaller than 10^{-6} cm can be resorbed.

It has also been found that the *law of optimum stimulations*, which seems to dominate all electro-biologic phenomena, is also applicable to the influence of aero-ionic currents. The influence might be favourable up to a certain maximum value, but this changes into a reverse effect if the optimum is surpassed. The optimum is different in various species of animals or plants, but sometimes also varies in the same species; e.g., growth of weak animals might be favourably affected by a negative ionic current, whereas in strong animals of the same species the same current has a retarding effect. This makes the study of aero-ionic effects extremely difficult, much more difficult even than the study of X-ray effects, as the phenomena observed with ionic currents are very weak compared with the X-ray effect.

TSCHYEVSKY used for his experiments the method of electric *effluviation*, i.e., flowing of static electricity from metal points with high electric potentials. For this purpose a metal grid containing 300 metal points per m², was suspended by insulated supports. The grid was charged up to 80,000—100,000 V. The biological object was placed abt. 1 m below the grid. The studies of TCHYEVSKY and DESSAUER and his pupils revealed that aero-ionic currents seem to effect a great number of biological phenomena, such as the function of nerves, growth, sexual functions, closing of wounds, blood pressure, number of erythrocytes in blood, respiration frequency, function of endocrinal glands, etc.

2. Mechanism of aero-ionic effects

During these different experiments the possibility of non-ionic factors was always taken into consideration. Two sources of disturbance during effluviation experiments are of particular importance: the influence of nitrogen oxides and ozone.

A. *Influence of nitrogen oxides:*

Flow of electric charges in air from highly charged conductors (even in slow flowing processes) transforms nitrogen of the air into NO, NO_2 and HNO_2 (nitrous acid, an unstable, active oxidizing agent) and develops ozone out of oxygen. Inspiration of the nitrogen gases in concentrations of 0.5-1 mg/l air for half an hour may have fatal results. Smaller traces cause neurotic depressions, heart trouble, decreased production of urine (oligury), etc.

B. *Influence of ozone* (O_3) (see also p. 69):

In 1840 SCHÖNBEIN found that mice die in air when the ozone content exceeds the ratio 1:6000.

In 1870 TCHEMEZOFF confirmed this observation and discovered that the action is due to inflammation of the lung tissues and the lack of capacity of ozone to be absorbed by the blood (see p. 78). During ultraviolet irradiation with a mercury lamp, ozone is developed in quantities of abt. 0.5 mg O_3/m^3—; at distances of 1-3 m—, 5-10 parts ozone on 10,000 parts of air were measured. Ozone remains undecomposed only when mixed with much oxygen. It can be smelt at concentrations of 10^{-6}.

Careful studies of TCHYEVSKY and his pupils showed, however, that the main effects of effluviation are due to aero-ionic currents.

TCHYEVSKY explained the aero-ionic effect by assuming two phenomena: transfer of electric charges from the air to the skin and penetration of electrically charged air into the membranes of the lungs, mouth and nose and probably also into the blood stream.

A. TRANSFER OF ELECTRIC CHARGES FROM THE AIR TO THE SKIN

On p. 248 we observed that the average air-earth current amounts to $8 \cdot 10^{-7}$ A/cm²/sec. This can be applied to the human body. Different calculations were made of the magnitude of the ionic current which reaches a human body of 165 cm length: according to DORNO it amounts to $1.96 \cdot 10^{-9}$ A; according to GRATSCHEWA to $3.57 \cdot 10^{-9}$ A; according to BARANOW to $5.4 \cdot 10^{-12}$ A; according to TCHYEVSKY, under his effluviation grid, to $3 \cdot 10^{-8}$ A/cm² (with a negative potential of 90 V and at 1 m distance from the grid). On p. 136 we saw that the rheobase of nerves varies between 10^{-6} and 10^{-4} A. On p. 129 we described the different nerve endings that terminate in the skin between 0.25-2.5 mm below the surface of the skin. It seems theoretically possible, therefore, that under special atmospheric conditions with high potential gradients and increased air-earth currents, certain nerve endings in the skin of people with low skin resistance (see p. 186) are stimulated. Two experiments, apart from those described on p. 186 and 328, support this assumption; general support is also found in the great electro-atmospheric sensitivity of certain people.

1. TIKOTSCHINSKAYA (1928) discovered that a negative ionic current, created by a static machine, changes the tactile and pain reactions of people.
2. According to RACHMANOFF, certain species of chickens, if placed in an ionic current for 4 hours a day, lose their feathers and stop laying eggs. This seems to be due to the great number of sensitive nerves in the skin of birds (see Bibl. No. 649).

B. PENETRATION OF ELECTRICALLY CHARGED AIR IN LUNGS AND BLOOD STREAM

This mechanism has been studied, in particular by CASPARI, PICARD, SOKOLOFF, TCHYEVSKY, DESSAUER, and LEIRI. Two processes occur:

2. B. 1. Adsorption phenomena

Ions which come into contact with the membranes in the nasal cavity, mouth cavity and lungs are repulsed or attracted, depending on the electric charge of the membranes (see p. 18). The attraction is either purely physical or chemical. The colouring methods of cell tissues are based on these adsorption phenomena. According to JANITZKY (1931) only 14-40% of heavy negative ions reaches the lungs during inhalation, 45% remains in the mouth. During 18 respirations per minute abt. 9000 cm³ air is inhaled, i.e., abt. 12.9 million cm³/day. If we assume that the total number of small and large ions per cm³ for each sign amounts

to 5,000 (see p. 243), each with the elementary charge of $15.9 \cdot 10^{-20}$ coulomb, the total electric energy that reaches the lung membranes in a day amounts to 10^{-8} C. The average diameter of the lung alveoli is abt. 250 μ and as the total number of alveoles in human lungs varies between $150 \cdot 10^6$ and $4 \cdot 10^9$, the total respiration surface amounts to 80-130 m², i.e., abt. 50 times the surface of the human body. This makes it possible to adsorb practically all ionic charges with a sign opposite to the membrane potential. According to BERSTEIN the charge of the membranes of alveolar cells is usually positive; this enables the membranes to adsorb mainly negative ionic charges (see also p. 141).

2. B. 2. Diffusion phenomena

If the ions diffuse through the membranes they reach the cell protoplasm. We saw on p. 141 that nerve and muscular cells are normally only permeable for cations; erythrocytes also allow anions to pass (see p. 77).

TCHYEVSKY found that with a certain ionic concentration, air — mainly composed of negative ions — retards the respiration frequency and has a quiescent influence, whereas positively charged air has the opposite effect. According to HOPPEL (1931) strongly concentrated positively charged air (10^7 ions/cm³) has the same biological effects as shortage of oxygen. TCHYEVSKY explained this with the repulsion of positive oxygen ions by the alveolar membranes, which creates a shortage of oxygen and surplus of CO_2 in the blood; this influences the blood pressure, composition of the blood, etc. Symptoms similar to ordinary oxygen shortage (as have been observed in subterranean caves, during mountain-sickness, etc.), whereas the actual oxygen content is not very low, seem to be caused by these electric phenomena.

Abt. 12.9 million cm³ air in one day comes into contact with abt. 10 million cm³ blood through the blood capillaries of the lungs. With an average content of 4-5 million erythrocytes/mm³ (see p. 77) and an average size of 6-8 μ, the total active blood surface in the lungs amounts to 2,816 m²/day. The total alveolar respiration surface is estimated to be 80-130 m² (see above). In other words the adsorption of aero-ions by the blood takes place rather easily.

3. Experiments on biological effects of aero-ionic currents (see also p. 255)

The experiments of TCHYEVSKY and DESSAUER and their pupils and of LEIRI a.o., indicate that a number of interesting biological effects, can be summarized as follows:

A. *Respiration frequency decreases* during respiration of mainly negatively charged air, positively charged air increases the frequency (see above); according to HOPPEL these phenomena are particularly evident with patients suffering from goiter. The feeling of oxygen shortage in

centrally heated rooms is, according to JANITZKY (see p. 243), the result of a surplus of positive ions near heated metal surfaces. The favourable effect on persons of the neighbourhood of water spray (in gardens, near waterfalls) might be due partly to the cooling effect, but probably also to the great number of negatively charged water droplets, which are blown away as a result of the LENARD effect (see p. 246).

B. *Blood pressure decreases* during inhalation of mainly negatively charged air.

C. *The sensitivity of nerves seems to increase* (according to TCHYEVSKY, (Bibl. No. 643 and EDSTRÖM, Bibl. No. 632) during treatment with negative aero-ionic currents (see also above, experiment of RACHMANOFF and TIKOTSCHINSKAYA); positively charged currents have the opposite effect. The mechanism of ionic action on nerves is rather complicated.
   1. Direct stimulation of receptor bodies of nerve endings in the skin (see above).
   2. Indirect stimulation, by energizing the blood in the lung capillaries, which is transferred to the brains and the central nervous system. This process probably consists of two separate actions:
      a. changes of the electric charges in the blood;
      b. changes in the electric conditions of the fluids surrounding the nerves.

D. *Influence of ionic currents on the health of cattle in cattle houses* was found by TCHYEVSKY (Bibl. No. 647 and 648).

E. *Increase of hemoglobin content* was observed by TCHYEVSKY when guinea-pigs were treated with negative aero-ions.

F. *Increase of erythrocytes* after treatment of pigs and cows with negative aero-ionic currents was observed by TCHYEVSKY. The number of leucocytes and the pH of the blood also changed. ZWETKOWA (1927) found the same after treatment of rabbits.

G. *Decreased settling speed* was observed by TCHYEVSKY and UTZ (between 1926 and 1930) after treatment of tuberculosis patients with negatively charged air. T. explained this with the greater stability of erythrocytes in the colloidal blood fluid by increased negative charge. Decreased stability causes agglutination and greater settling speed. Miss LANDA-GLAS demonstrated in the Brain-Research Institute at Moscow that blood serum colloids in the presence of aluminium precipitate more slowly in the presence of negative aero-ionic currents than in their absence; positively charged ions increase the precipitation speed. Periods of increased *embolism* (particularly after operations) in different parts of the world, might be related to similar atmospheric phenomena. The great practical importance for medical science of TCHYEVSKY's discovery, if confirmed by other scientists, is evident.

H. *Influence on bacteria in bloodstream:* changes of the electric charges of the blood stream and of the pH might affect the living conditions of bacteria (see DE-KRUIF-NORTHROP effect, p. 55).

I. *Increase in rheumatic pains* was observed by LEIRI (Bibl. No. 641) when patients were treated with negative ionic currents, both with subacute and chronic rheumatism. LEIRI pointed out that stability in the cells is only possible if an equilibrium exists between negatively charged micellae and positively charged surrounding fluid. If the potential difference between both components decreases, a precipitation occurs which might be irreversible. Presence of negative ions seems to decrease the positive charges to such an extent that there is jellification in the muscular tissues. Heating followed by *increased blood circulation increases the diaphragm currents* (see p. 152); it might increase the positive charges and re-establish the stability of the colloidal fluids in the tissues. According to LEIRI this would be one of the main causes of succesful heat-treatment of rheumatic pains.

J. *Increased regeneration of open wounds*, after treatment with a negative aero-ionic current, was observed by TCHYEVSKY (Bibl. No. 653) and PEREDELSKY. It was known that during the primary stages of wound infection a great surplus of positively charged H ions occurs in wound excretions. The acidity decreases and generally returns to normal when the inflammation is over. The regenerational processes of wounds appear to be counteracted by this high content of H ions. In 1933 A. A. PEREDELSKY proposed the treatment of wounds with negatively charged air. 18 mice (8 male and 10 female) were wounded artificially on the back. Their wounds were treated with a negative ionic current every day for 15 minutes. The number of ions amounted to 3,000,000/cm^3, giving on the back a current of $16.5 \cdot 10^{-10}$ A/cm^2. The experiments gave the following results:

1. wounds treated with a negative ionic current regenerated 15% more quickly than with normal regeneration;
2. With irradiated wounds the regeneration time is directly proportional to the surface of the wound at the beginning of the treatment; with normal non-irradiated wounds the regeneration time was very irregular.

   It is evident that these experiments must be repeated with hundreds of mice before results can be regarded as conclusive. However, it shows again another possibility of the influence of atmospheric conditions on the general health of living organisms.

K. *Influence on the general health condition:* not only the sign of the ions, but also changes in the concentration seems to be responsible for mountain-sickness and other atmospheric diseases. *Psychotechnical tests*, carried out in negatively charged air give *better results* than in ordinary air.

L. *Influence of the skin potential:* on p. 173-182 we discussed the electric skin potentials and we learned that considerable electric

potentials of different sign are present on the human skin. They cause certain ionic charges to be attracted and others to be repulsed, which may be another factor in the specific atmospheric sensitivity of certain people.

This short review of the influence of atmospheric ionic currents may show the complexity of this problem. Nevertheless we have seen that important biological effects can be created by atmospheric changes, which might be responsible also for several of the divining phenomena, particularly dowsing. Further intensive study of the electro-biological effects of the atmosphere might prove to be of great value to surgeons (see A and G), schools (see K) and to medical science in general.

PART III: INFLUENCE OF MAGNETIC FIELDS
(see Bibl. No. 214-259, 377-382, 654-686)

We discussed on p. 76-79 the *fundamental magnetic properties* of a number of important organic substances and we gave a review of the *six main fundamental processes responsible for the bio-magnetic effects in living matter* if they are subjected to magnetic fields (see p. 79-83). We have seen that *the law of constancy of excitation energy* (see p. 83 and 99) can also be applied to bio-magnetic phenomena; in other words small magnetic forces acting continuously for long periods can create deformations similar to the effects created by large magnetic forces in short periods, the only condition being that the small magnetic forces surpass the internal "limit of elasticity" for biomagnetic deformation (see p. 83-84).

Although from a theoretical point of view biomagnetic effects without any doubt exist, experiments to demonstrate these effects are not very wellknown in physiological literature. We have not been able to obtain information on biomagnetic effects in any physiological laboratory in England or Holland and even the 1,744 pages American volume on "Medical Physics" (1944), edited by O. Glasser, fails to mention any experiment on biomagnetic phenomena. It is for this reason that we have compiled all the literature on this subject; a short summary is given in this chapter. The results of these biomagnetic experiments are of great importance for the understanding of dowsing phenomena (chapter III).

Before we discuss each of these experiments separately, it would be useful to give a brief survey of the observed biomagnetic effects. Experiments carried out by the author on the influence of magnetic fields on muscular contraction during dowsing experiments are omitted and will be discussed in chapter III, p. 319.

1 *Experiments with plants*:
- A. influence on plasmatic cell-rotation
  - a. exp. of Ewart (1903; Bibl. No. 227)
  - b. exp. of P. W. Ssawostin (1926; Bibl. No. 680)
- B. influence on growing speed (magneto-nastics, see p. 100)
  - exp. of P. W. Ssawostin (1931; Bibl. No. 681)

2. *Experiments with animals:*
   A. influence on animal tissues
      a. exp. of J. LENGYEL (1932—'34; Bibl. No. 664-665; fig. 74 and 75)
      b. exp. of T. HUZELLA (1934; Bibl. No. 660)
      c. exp. of R. PAYNE SCOTT and H. LOVE (1935; Bibl. No. 677)
   B. influence on mitosis
      a. exp. of M. LENZI (1934: Bibl. No. 671)
      b. exp. of E. DE LORENZI (1934; Bibl. No. 673-674)
   C. influence of chromosomes
      a. exp. of J. KUWADA (1928; Bibl. No. 662)
      b. exp. of E. DE LORENZI (1934; Bibl. No. 673-674; fig. 76)
   D. influence on giant-cell formation
      a. exp. of J. LENGYEL (1932; Bibl. No. 664; fig. 77)
      b. exp. of T. HUZELLA (1934; Bibl. No. 660)
      c. exp. of E. DE LORENZI (1934; Bibl. No. 673; fig. 78)
   E. influence on cancer:
      exp. of M. LENZI (1934-1939; Bibl. No. 671; fig. 79 and 80)
      a. with constant magnetic fields
      b. with alternating magnetic fields
   F. influence on skin regeneration of wounds:
      exp. of M. LENZI and G. MUZZIOLI (1937; Bibl. No. 668; fig. 81)
   G. influence on blood pressure;
      exp. of T. SAITO (1935; Bibl. No. 679)
   H. influence on erythrocytes:
      a. exp. on settling speed of M. LENZI (1938; Bibl. No. 671. fig. 82)
      b. exp. of A. CARDIN (1932; Bibl. No. 225)
   J. influence on ovulation:
      exp. of FASOLA and PIERALLINI (1939; Bibl. No. 671)
   K. influence on growth (of mice):
      exp. of S. W. TROMP (1947; not yet published)
   L. influence on general condition:
      exp. of T. SAITO (1935; Bibl. No. 679)
3. *Experiments with man:*
   A. pain-deadening influence:
      exp. of K. M. HANSEN (1934-'38; Bibl. No. 658)
   B. influence on inflammations
      exp. of K. M. HANSEN (1934-'38; Bibl. No. 658)
   C. influence on oxygen absorption
      a. exp. of V. MARAGLIANO (1902; Bibl. No. 675)
      b. exp. of W. MÜLLER (1902; Bibl. No. 676)
      c. exp. of K. M. HANSEN (1942-'43; Bibl. No. 659)
   D. influence on general nervous condition
      a. exp. of BIRCHER (1900; Bibl. No. 675)
      b. exp. of RODAZI (1901; Bibl. No. 675)
      c. exp. of ISCHEWSKY (1901; Bibl. No. 675)
      d. exp. of FRANKENHAUSEN (1902; Bibl. No. 675)
      e. exp. of LILIENFELD (1902; Bibl. No. 675)
      f. exp. of MÜLLER (1902; Bibl. No. 675)
   E. influence of magnetic field of the earth:
      a. exp. of A. M. ALVAREZ (1934)
      b. exp. of S. W. TROMP (1947; Bibl. No. 684)
4. *Experiments with micro-organisms*
   A. exp. with bacteria
      1. influence on growth:
         α. exp. of F. P. LEUSDEN (with Bacterium Coli and Staphylococcus, 1928; Bibl. No. 672)
         β. exp. of M. LENZI (with Bacillus pyocyaneus, 1939; Bibl. No. 671)

γ. exp. of F. M. SUMMERS and H. K. HUGHES (with Colpidium campylum, 1939; Bibl. No. 683)

2. influence on mobility:

α. exp. of CHEMEVEAU and BOHN (with Loxophyllum and Colpidium colpoda, 1902; Bibl. No. 655)

β. exp. of W. D. FRANCIS (with Leptothrix Ochracea, 1935; Bibl. No. 657)

B. experiments with moulds

a. exp. of PIROVANO (1935, Bibl. No. 669)
b. exp. of M. LENZI (1938; Bibl. No. 669; fig. 83)
c. exp. of K. KIMBALL (1938; Bibl. No. 661)

This brief review indicates that the greatest amount of experimental work on biomagnetic effects has been carried out by Italian scientists, particularly in the Radiological Institute at Modena (Italy), under directorship of Prof. A. BALLI; a number of radiologists in this institute studied the biomagnetic phenomena over a period of 5 years (1934-'39), the most interesting studies being made by LENZI, LIVI, MUZZIOLI and DE LORENZI. A compilation of their work was given by LENZI in 1940 in Bibl. No. 671. These studies were preceded in 1902 by the experiments made by MARAGLIANO.

Each of the above-mentioned experiments are discussed briefly in the following pages.

1. A. Experiments on cell rotation

EWART studied the influence of strong magnetic fields (exact figures not given) on the rotation of plasma in plant cells (see p. 13). He noticed changes in the rotation only if the axis of the cell was perpendicular to the lines of force. If they were parallel no changes were observed.

In 1924 SSAWOSTIN continued the experiments of EWART and others, first in the physiological institute of Odessa, later in the botanical laboratory at TOMSK (Russia), and finally in the botanical institute at Leipzig (Germany).

Rotation of cell plasma was discovered in 1774 by CORTI in Chara species and was attributed by AMICI in 1818 to electric currents. Experiments of BECQUEREL (1837), DUTROCHET (1847) and REINKE (1882), however, did not confirm the theory of AMICI. Strong magnetic fields, which would influence the rotation if they were caused by electric currents, could not be observed. SSAWOSTIN, however, improved the methods considerably. He used large electro-magnets with a constant magnetic field with a field strength of 3,000-7,000 Gauss. A Reichert microscope was placed between the poles of a horseshoe magnet on a wooden table. The movements of chloroplasts were studied under the microscope. The influence of the increase in temperature between the poles of the electro-magnet (only 0.5° C in 20 minutes) was taken into consideration. It created an increase in rotational speed of maximal 2 μ/sec. As the measurements never lasted more than 6 minutes this temperature influence can be neglected. SSAWOSTIN used cells from the central nerve of leaves of

Vallisneria spiralis (a kind of waterthyme) and cells from leaves of *Helodea canadensis*. Altogether 70 experiments were carried out of which only 8 gave negative results.

The following positive results were obtained:

1. a constant magnetic field increases or slows down the rotational speed of cell-plasma. The change in velocity amounts to abt. 0.135 cm/sec;
2. the kind of change depends on the relationship between the longitudinal axis of the cell and the direction of the lines of force; if both are parallel the rotational velocity is decreased, if they are perpendicular to one another, either increase or decrease of velocity might occur;
3. the increase in velocity is generally greater than the decreasing effect and is less dependent upon the field strength than the decrease;
4. the plasma reacts on a magnetic field either directly after the field is put on or some little time afterwards;
5. the plasmatic movements react on changes in polarity of the poles of the horseshoe magnet;
6. with the formula $F = Hids.$ sine (in which F = field strength acting on the plasmatic current, i = electric current in the plasma, ds = displacement by the plasmatic current, e = rotational angle); SSAWOSTIN calculated a value for $i = 0.4 \cdot 10^{-5}$ A.

SSAWOSTIN explained these bio-magnetic effects by assuming three processes:

1. influence of the magnetic field on magnetic particles in the cytoplasm (see p. 57);
2. influence on the orientation of micellae perpendicular to the cell wall; this creates an increased friction between cell wall and cytoplasm;
3. magneto-chemical effects (see p. 82);.

1. B. Experiments on growing speed

In 1926 SSAWOSTIN, in the botanical laboratory of TOMSK (Russia), studied the influence of constant magnetic fields with field-strength of 200-2,150 gauss on the growth of the primary leaves of wheat. During these experiments the lines of force were perpendicular to the longitudinal axis of the leaf. The plants of 40-60 mm height were placed in a thermostatic box; the growing speed was read with a microscope. The following results were obtained:

1. 11-13 minutes after the field was put on the growth increased considerably if the lines of force were perpendicular to the leaf;
2. if the top of the plant was also in the field, the increase in growth was considerably less;
3. the growing speed increased gradually, usually until a maximum was reached, after which it remained constant; if the field were cut out, a renewed increase in growth was observed which indicates that the magnetic gradient (in time) is a more important factor than

the actual field strength. A similar phenomenon was observed by the author during experiments with man (see p. 322);

4. In weak or very strong magnetic fields the maximum growing speed increased exponentially with the increase of the field-strength; in magnetic fields of medium field strength the magnetic influence decreased with increasing field-strength;
5. no changes in curvature were observed which suggests that not mechanical displacements of magnetic particles took place;
6. the *magneto-growing effect* was observable in all plants between 12 and 2 p.m.; this increase did not occur in all plants in early morning and evening.

In 1929, similar experiments were carried out in the botanical laboratory at Leipzig (Germany). Ssawostin studied the influence of magnetic fields on the growth of the Koleoptiles of oats if the magnetic lines of force were parallel to the Koleoptiles.

In order to study the influence of magneto chemical effects created by the paramagnetic elements, iron, manganese and oxygen, iron and magnesium salts were added to the soil of those plants. The following results were obtained:

1. No magneto-growing effect was observed in constant magnetic fields, with field strength of 1,600 Gauss and with lines of force parallel to the direction of the growth of the Koleoptiles.
2. If the field strength were relatively small (60 Gauss) the increase in growing speed was considerable.
3. If 0.001 Normal solution of manganese nitrate was added to an ordinary feeding solution of Tottingham, the growing speed increased by 40%.

The explanation of the magneto-growing effects in plants is extremely difficult and many more experiments are required before this problem can be solved. It is known that the growth of plants is due to certain *growing agents* — the *auxines* — and that growing speed can be checked by *checking agents*. Recent studies have revealed that structurally a great similarity exists between the growing and checking agents, which can easily replace one another, depending on subtle changes in the physico-chemical conditions in the plants. It is difficult to say at present whether magneto-chemical reactions are responsible for the difference in activity of the auxines, or whether directive forces change the diffusion and circulation channels in the plants. Considerably more research work needs to be carried out before this problem can be solved.

2. A. Experiments on animal tissues

Julia Lengyel, a pupil of Prof. Huzella (Director of the Anatomic Biological Institute at Debrecen, Hungary), about 1932. studied the influence of a constant magnetic field (which could lift 300 kg) on

the heart tissue of chicken embryos in vitro over a period of 48-72 hours. HUZELLA discovered in 1931 that heart tissue in vitro has a very characteristic histological structure (see fig. 74). The magnetic field creates a completely different tissue structure (see fig. 75) with several multinuclear giant-cells.

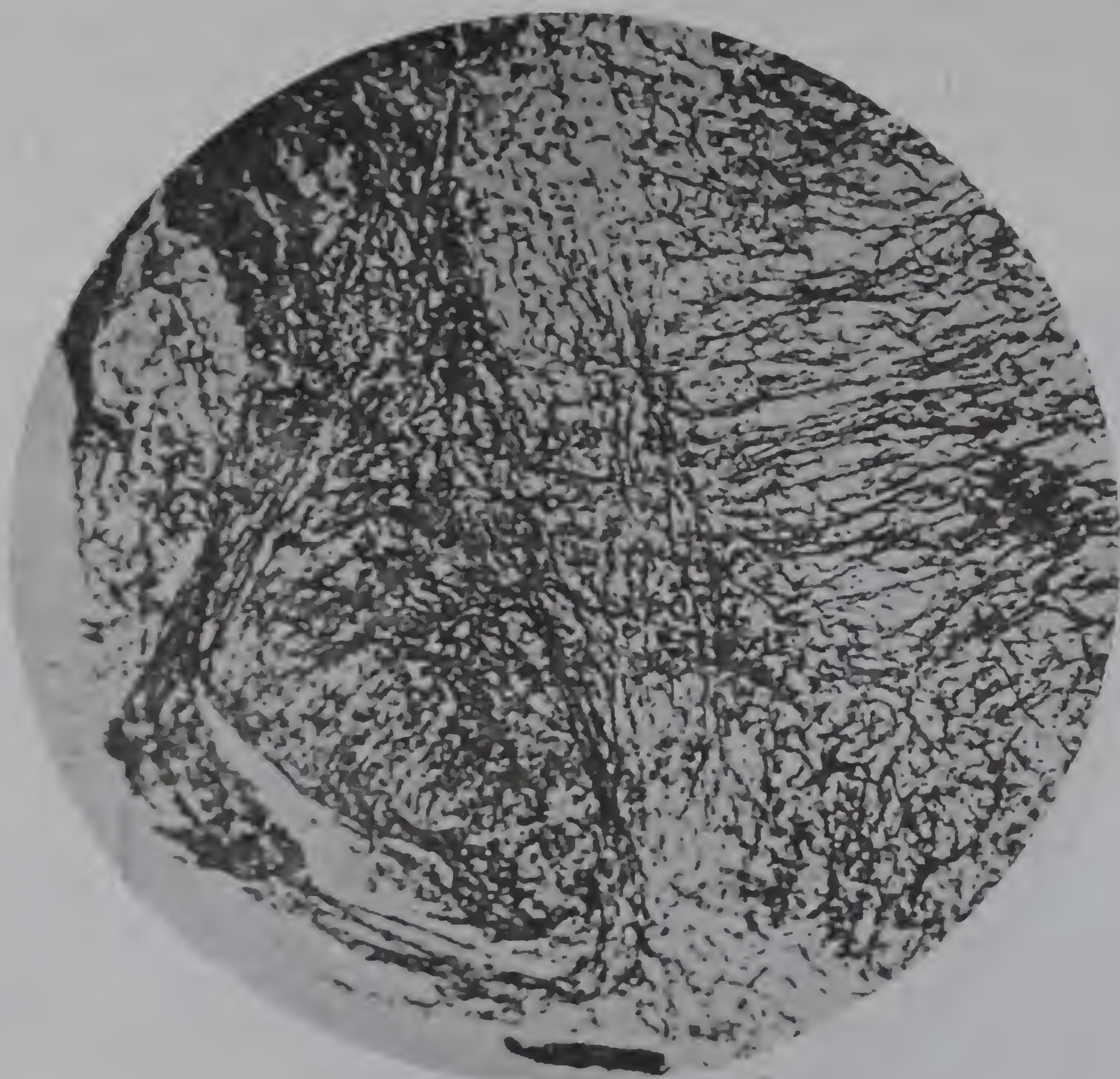


Fig. 74: (Bibl. No. 664, fig. 6) Heart tissue of chicken embryo showing the structure of HUZELLA, with its typical system of argyrophyll fibres.

HUZELLA repeated these tissue experiments with alternating magnetic fields of 30,000 gauss. After only 24 hours a pronounced orientated spindle-shaped tissue growth towards the magnetic poles was observed.

R. PAYNE SCOTT and H. LOVE, at the Cancer Research Laboratory at Sydney (Australia) repeated the experiments of LENGYEL and HUZELLA. They used constant magnetic fields of 5,000 Gauss for only 3-6 hours. They were unable to observe any agglutination of chromosomes (see further), but there occurred slight protoplasmatic changes in the cells The experiments were not carried on long enough to obtain the LENGYEL-HUZELLA phenomena. The explanation of these tissue changes is not yet known but might be related to the directing effect of magnetic forces on paramagnetic substances in the tissues. It might be the result of the indirect influence of magnetic fields on growing and checking agents. HEATON discovered in 1926 that growth of heart

tissues of chicken embryos was checked by certain chemical checking agents. LETTRÉ observed a similar influence of checking agents on mitosis. A great number of experiments must be carried out before we can solve the cause of these bio-magnetic effects. The important fact remains, however, that tissues in the body seem to be influenced permanently by the action of magnetic fields.

Fig. 75: (Bibl. No. 664, fig. 7) Same tissue of fig. 74 growing in a constant magnetic field (with a power of 300 kg) for 48-72 hours. The picture shows irregular fibre structures, the fibres often clotted together into bundles.

2. B. Experiments on mitosis

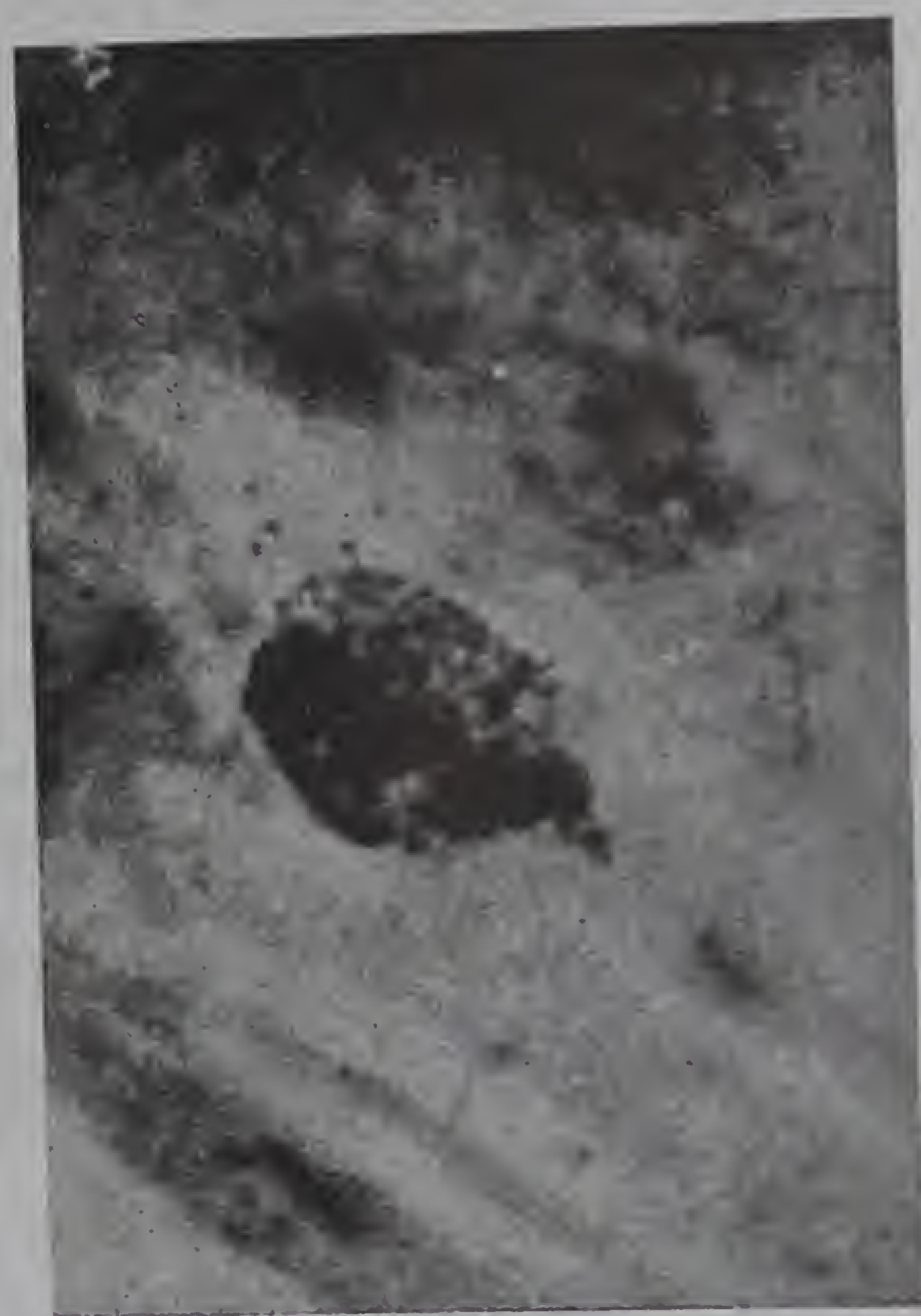
LENZI and DE LORENZI repeated the experiments of LENGYEL with other tissues. The following results were obtained:

1. No striking changes in the orientation of cells were observed but a pronounced increase of the mitosis coefficient (from 9.6 to 16.9) occurred.
2. The anaphase during cell-division is prolonged in short exposures of tissues to weak magnetic fields; this causes an apparent increase of the mitosis coefficient.
3. Other mitotic anomalies, such as the formation of giant-cells, agglutination of chromosomes, division not according to planes of symmetry, etc., have been observed. The deeper causes of these

anomalies are not yet known, but they are most likely related to one or more of the basic processes. The latter are discussed on p. 79-83 (see also above, influence of checking agents on mitosis).

2. C. Experiments on the influence of chromosomes

KUWADA made some experiments with floating magnets and came to the conclusion that the phenomena created between these magnets are comparable to the biologic field created by chromosomes in cells. He therefore assumed that magnetic fields should influence the chromosome arrangements in cells.



A B

Fig. 76: (Bibl. No. 671, fig. 2 and 3) A) Beginning of agglutination of chromosomes in a cell; B) agglutination process is completed, followed by a general disintegration of the cell.

A confirmation of this assumption seems to be obtained by DE LORENZI, who discovered agglutination phenomena of chromosomes if cells were subjected to strong magnetic fields (see fig. 76).

2. D. Experiments on giant-cell formation

We mentioned previously that both LENGYEL and HUZELLA observed giant-cell formation in their magnetic experiments (see fig. 77). DE LORENZI (see above) observed the same phenomena during his experiments on mitosis (see fig. 78).

2. E. Experiments on cancer

Lenzi and his colleagues made some interesting experiments on the influence of magnetic fields on carcinoma. White mice were grafted with cancer tissue. They usually died within 30-40 days of Ehrlich adeno-

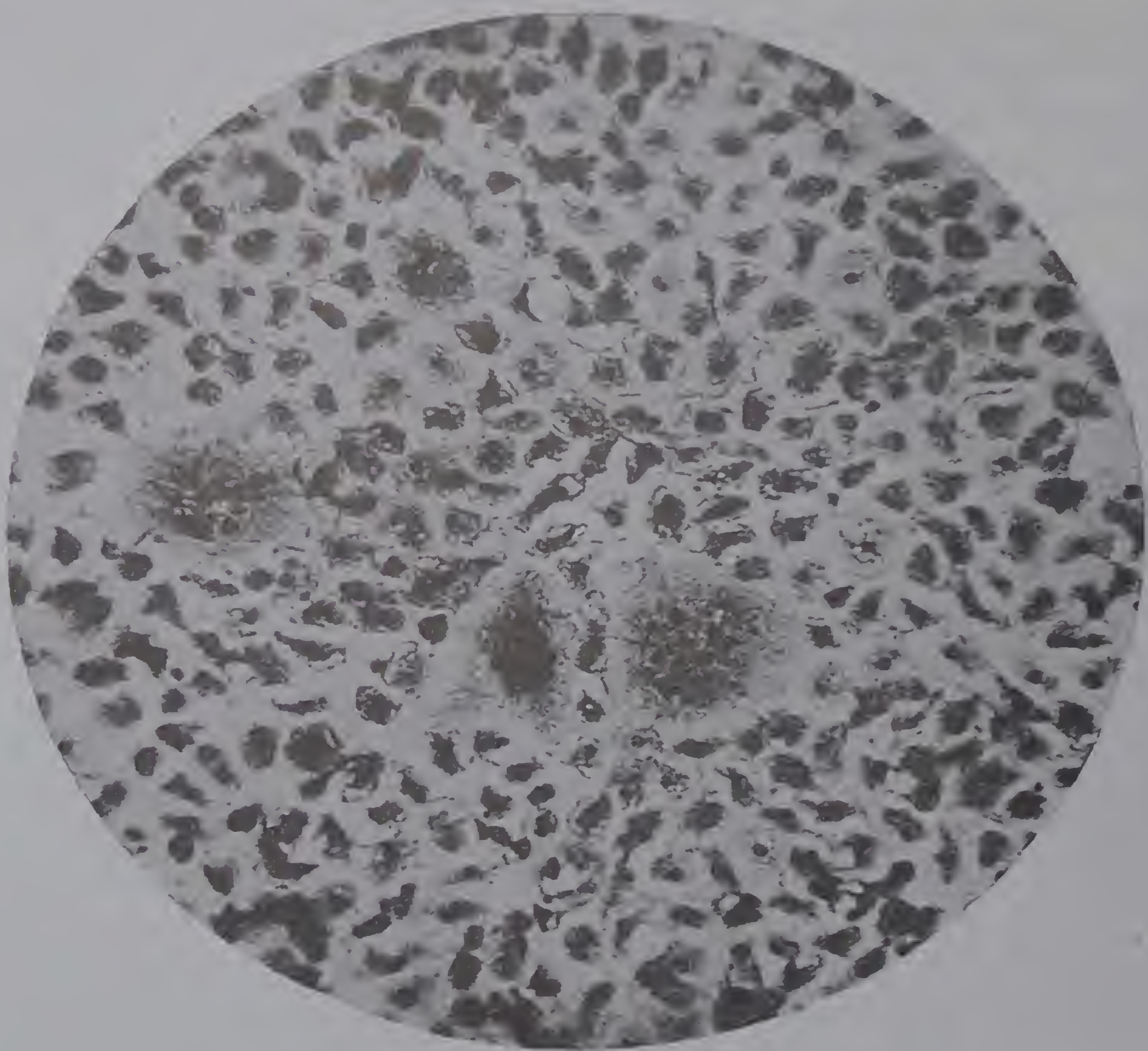


Fig. 77: (Bibl. No. 664, fig. 9) Development of giant cells with two or more nuclei in the heart tissue of a chicken embryo, the result of a strong magnetic field (see fig. 78).

carcinoma. After the average sensitivity of 100 mice was determined with 286 mice the following experiments were carried out:

1. the grafting substance was first placed in a constant magnetic field of 1,500 gauss, before the grafting took place. The development of cancer was practically the same as if ordinary grafting substance was used. Only between the 8th and the 12th day after grafting did the magnetized grafting substance appear to be slightly more active (see fig. 79 A). The effect of alternating fields is indicated in fig. 79 B.
2. The mice were grafted and immediately afterwards placed in a magnetic field for 8 hours a day.
   a. Constant magnetic fields were used in the first experiment. Six days after grafting a considerable retardation of cancer development was observed (see fig. 79C). If the field was cut after

the 12th day, the development was the same as that of the controls.

b. The same experiment took place in an alternating magnetic field (frequency 42/sec); the retardation effect was considerably stronger than with constant fields (see fig. 80). On the 12th day after grafting 92 per cent of the mice outside the magnetic field had taken carcinoma, against only 25 per cent in the field. After the field was cut out, no further increases occurred.

Fig. 78. (Bibl. No. 673) Creation of polynucleated giant cells due to magnetic fields (magnification 1170 ×).

3. Mice grafted 12 days previously and which demonstrated clearly cancer symptons were placed, for a period of 15 days, 8 hours a day, in a magnetic field.
   a. The development sometimes was retarded, sometimes accelerated in constant magnetic fields.
   b. No difference with the controls could be seen in alternating fields (frequency 42/sec.)

2. F. Experiments on skin regeneration

LENZI and MUZZIOLI studied the influence of magnetic fields on the regeneration of wounds created artificially on the legs of 37 mice of the same weight, sex and age. The surface of the wound was measured with the CARRELL-HARTMANN planimeter. The experiments with constant magnetic fields of 1,500 Gauss showed that during the first 13 days there was a retardation in the regeneration, but during the following 19 days an acceleration, compared with the controls (see fig. 81).

2. G. Experiments on the influence on blood pressure

T. SAITO made some experiments, at the Gynecological Institute of the Kyoto Imperial University (Japan), on the influence of alternating magnetic fields (frequency 60/sec) on rats and rabbits. The blood pressure was first measured for 10 minutes without a magnetic field.

A slight increase in blood pressure was observed if the field was put on.

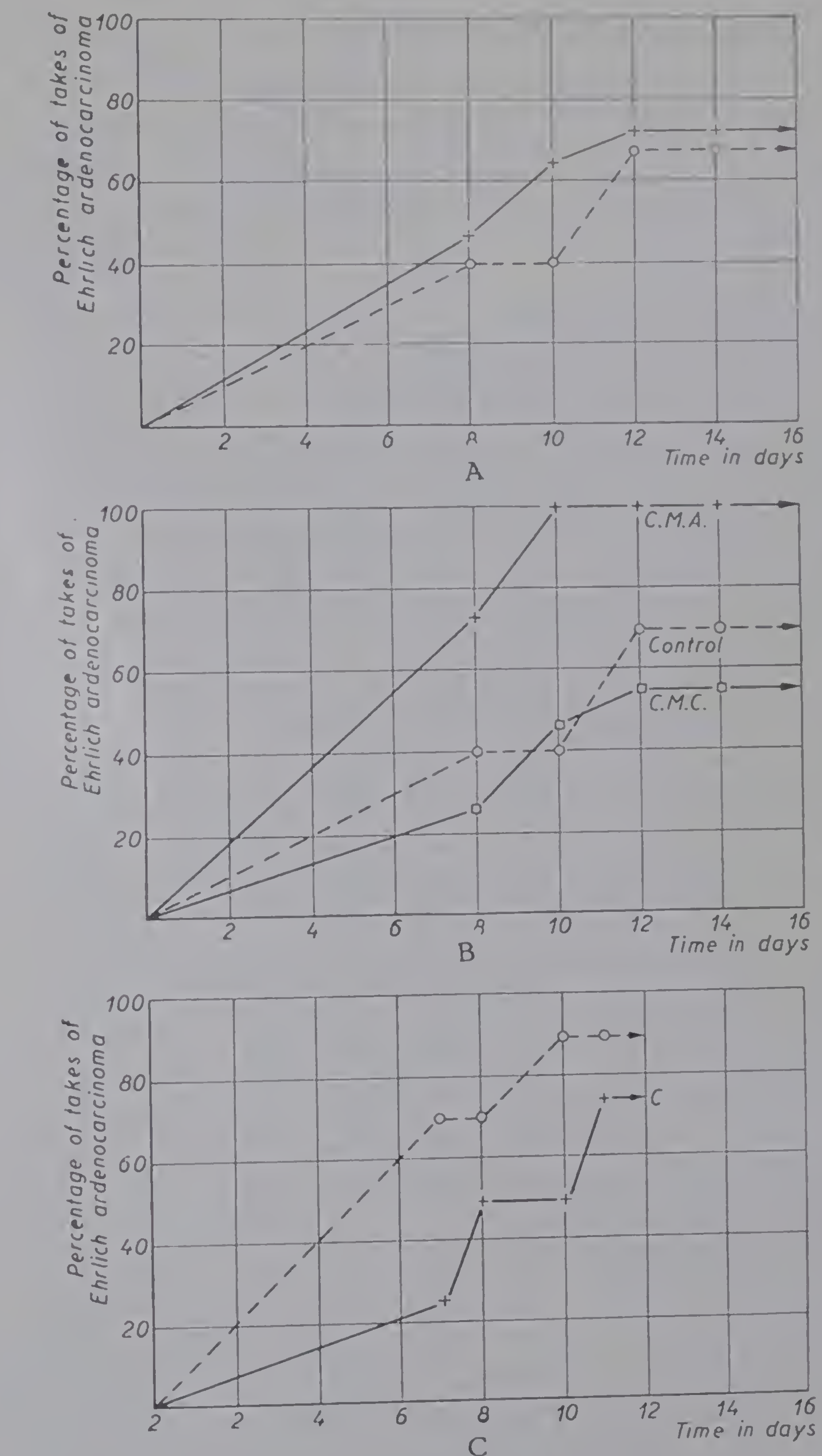


Fig. 79: (Bibl. No. 670, fig. 6 and 7) Diagram indicating influence of magnetic fields on cancer. Dotted lines = controls; solid lines = number of "takes" of EHRLICH ardenocarcinoma in magnetic field.
A) Tumour fragment placed in a constant magnetic field of 1,500 Gauss prior to grafting. After grafting, mice kept in same constant magnetic field.
B) Tumour fragment kept in alternating field (frequency 42/sec) prior to grafting. After grafting, part of mice kept in alternating field (C.M.A.), part in constant field (C.M.C.).
C) Mice were grafted with ordinary tumour fragments and soon afterwards placed in a constant magnetic field of 1,500 Gauss for 8 h/day.

←

Fig. 80: (Bibl. No. 670, fig. 8 and 9) A) Mice were grafted with tumour fragment and soon afterwards placed in an alternating magnetic field with a frequency of 42/sec. Dotted line = controls; solid line = animals in magnetic field.
B) Development of grafted tumours after interruption of treatment with magnetic fields.

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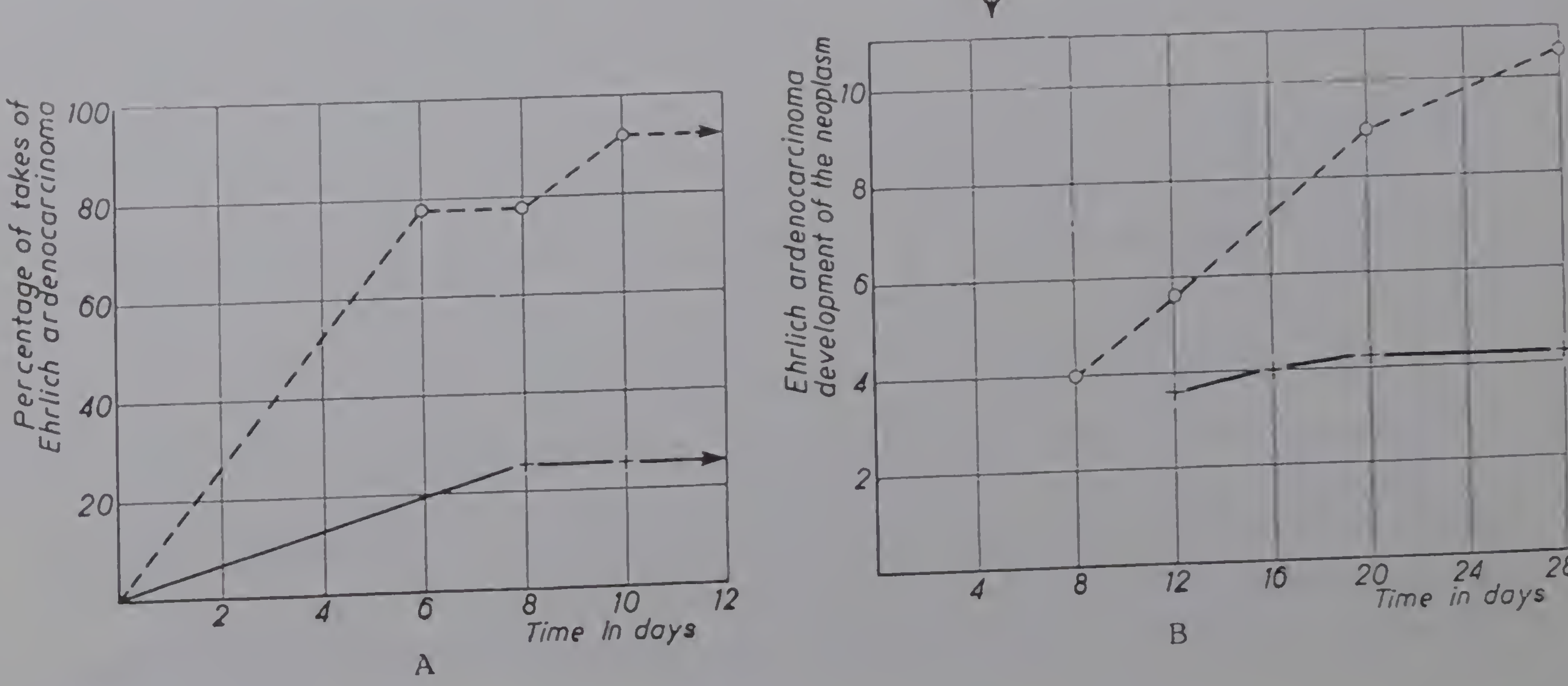

2. H. Experiments on settling speed of erythrocytes

Lenzi found that the settling speed of erythrocytes in human blood was increased if it was subjected to constant magnetic fields or to low-frequency alternating fields (42-650/sec). Pulsating magnetic fields and high-frequency fields (900/sec) decrease the settling speed (see fig. 82). The decrease occurs only during the first moments of settling; the latter afterwards seems to be normal (in high-frequency fields).

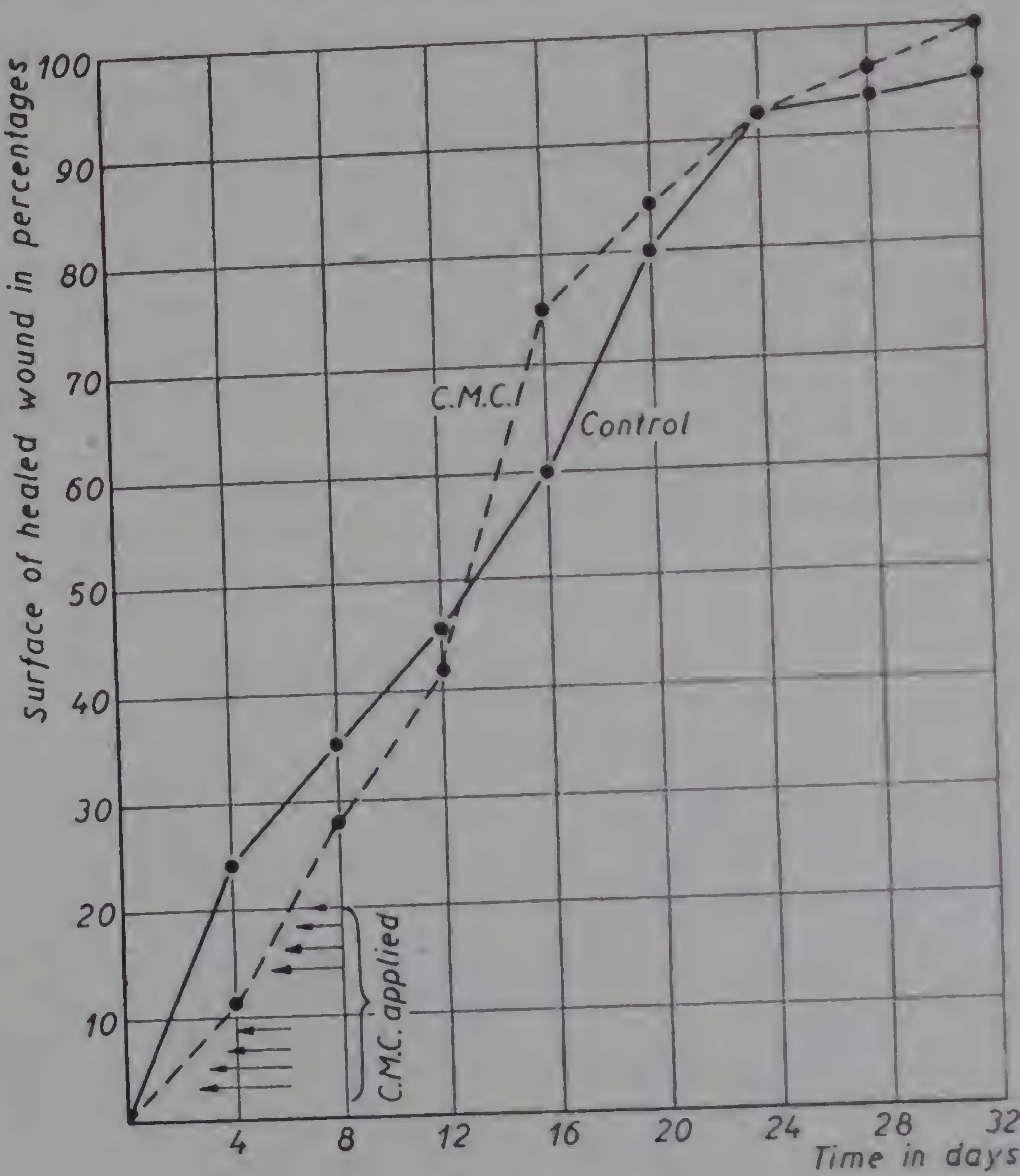

Fig. 81: (Bibl. No. 670, fig. 5) Healing of cutaneous wounds in a continuous magnetic field; C.M.C. = constant magnetic field.

The increase with constant fields takes place mainly in the last part of the settling process.

We mentioned on p. 79 the attraction of erythrocytes by the S. pole of magnets (*experiment of* Cardin).

2. J. Experiments on ovulation

Fasola and Pierallini did not observe any influence of constant magnetic fields on ovulation, but pulsating and alternating fields seem to accelerate the ovulation.

2. K. Experiments on growth of mice

In the Zoological Laboratory at Leiden (Holland), the author made some experiments on the influence of constant magnetic fields on the growing speed of mice. Experiments were carried out between March 17th, 1947 and August 5th, 1947. The changes in weight rather than

the growing speed were measured daily, as much as possible at the same time each day.

The tested animals consisted of 6 young white mice belonging to the same litter, of which two were males and 4 females; 6 gray mice were also used, of which 3 were males and 3 females; finally 14 newly born mice were tested. The 6 white mice were divided into two groups: one male and three females lived in the magnetic field, one male and one female lived outside. Each of the six animals was placed in a separate glass basin (17 · 15 · 18 cm) with some peat litter on the bottom (abt. 2 cm thick). The aquariums were closed with glass plates, leaving only a narrow gap of 1 cm wide for fresh air to enter.

The magnetic field was created by a tangent galvanometer of 1 m diameter (see fig. 96), with axis of the ring directed N 23° E/S 23° W. The basins were placed in front of this ring on a wooden table. The field strength in the centre of the ring amounted to 0.314 gauss. The experiments were carried out in a completely dark room in a cellar, abt. 1 m below the surface of the earth. During the daily feeding and weighing, which lasted abt. 1 hour, a covered white electric lamp illuminated the room. The animals were fed daily with a mixture of powdered corn and water placed in a small basin and a spoonful of wheat. Before the actual experiment started on March 22nd, 1947, all the animals were kept for a week in the cellar without any magnetic fields in order to enable them to accommodate themselves to the experimental conditions. Each day the weight of the mice, the temperature of the room, barometric pressure and the electric current through the tangent galvanometer were registered.

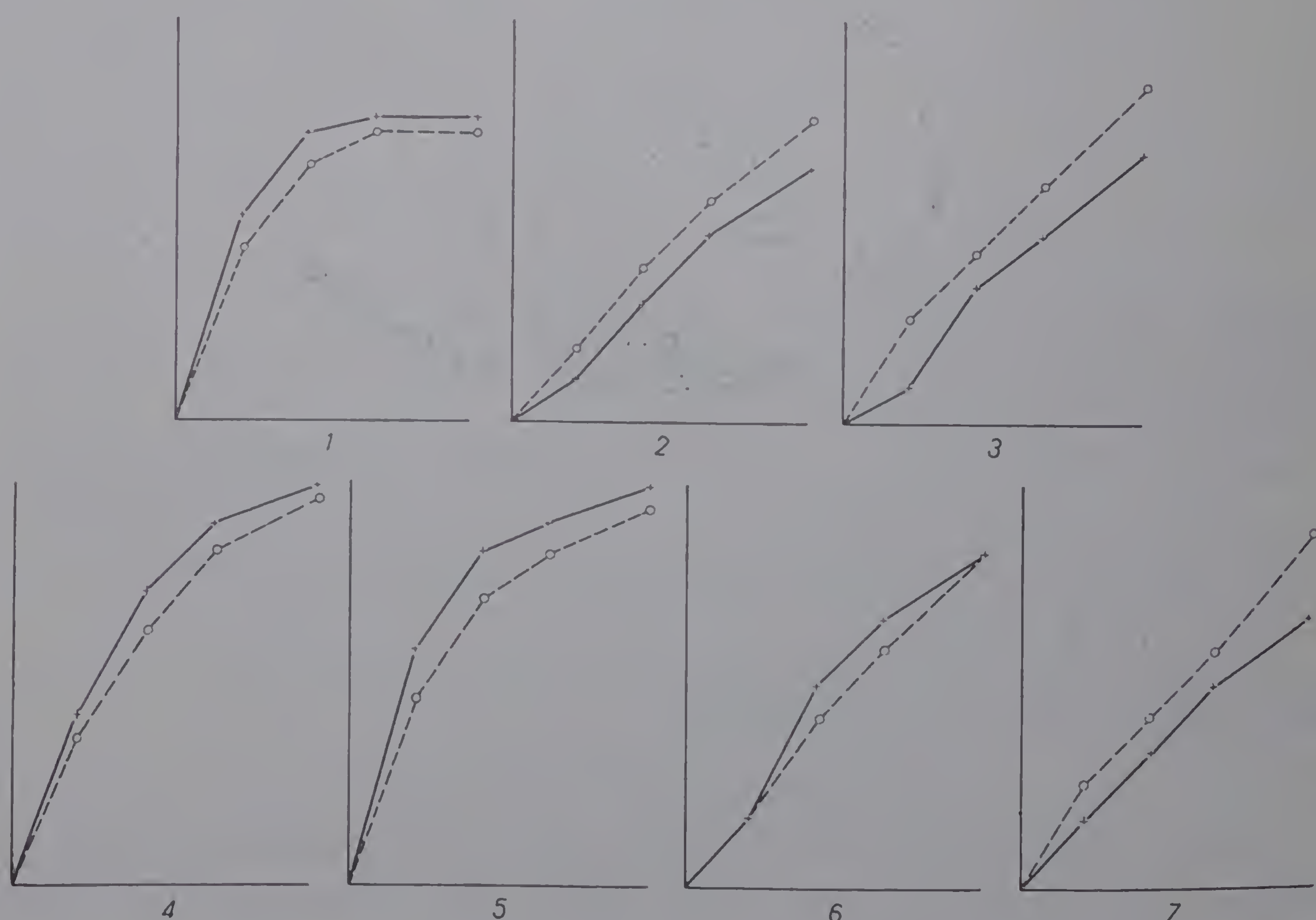

Fig. 82: (Bibl. No. 671, p. 232) Influence of magnetic field on settling speed of human blood at 18° C. Dotted line = controls; solid line = settling speed in magnetic field; vertical axis indicates height of plasma column in mm; abscissa indicates time in minutes.

1) Continuous magnetic field; 2) pulsating field with 3.3 pulsations/sec; 3) same with 16.6 pulsations/sec; 4) alternating magnetic field with a frequency of 42/sec; 5) same with frequency of 466/sec; 6) same with frequency of 653/sec; 7) same with frequency of 933/sec.

TABLE I

No. of animal	Magnetic deviation	Colour	Sex	Original weight (in g)	Difference in weight with initial weight (in grams)																	
					date 29/III '47	5/IV	12/IV	19/IV	26/IV	3/V	10/V	25/V	31/V	7/VI	13/VI	28/VI	5/VII	14/VII	19/VII	26/VII	1/VIII	5/VIII
1	13°	white	female	21.8	—0.3	+0.7	—0.3	+1.2	+0.2	+0.7	+0.7	+2.7	+1.2	+1.2	+ 2.2	+ 4.7	—0.3	—2.3	—2.8	— 3.3	—5.3	— 6.8
2	23°	white	male	23.0	—2.7	0	+1	+3.0	+3.0	+1.5	+2.0	+4.5	+5.0	+6.0	+ 4.5	+ 4.5	+5.0	+5.0	+6.0	+ 4.0	+ 4.0	+ 3.5
3	6°	white	female	21.0	—0.5	+0.5	0	+2.0	+2.5	+2.5	+2.5	+5.5	+4.0	+5.0	+ 4.0	+ 5.5	+3.0	+5.5	+7.0	+ 7.8	+ 9.1	+10.5
4	18°	white	female	17.0	+1	+3	+2.5	+3.5	+4.0	+4.0	+3.5	+6.0	+6.0	+6.3	+ 7.1	+ 5.5	+4.5	+8.0	+8.8	+10.0	+11.5	+13.0
5	1°	white	male	20.5	0	+1	+2.5	+5.5	+4.5	+5.2	+5.5	+6.5	+6.3	+6.6	+ 6.5	+ 6.0	+5.5	+5.5	+5.5	+ 6.0	+ 5.5	+ 5.5
6	0	white	female	19.0	+1.2	+2	+2	+4.5	+5.0	+6.5	+7.5	+8.0	+7.8	+9.1	+10.2	+12.0	+5.0	+2.5	+1.0	+ 1.0	— 1.5	— 3.0
temperature in centrigrades					16.2	13.8	14.6	16.4	15.0	14.0	16.6	17.0	18.8	18.8	17.6	20.2	20.4	18.6	20.0	23.4	23.2	23.4
barometric pressure in atmospheres					77.0	77.0	78.0	76.6	77.5	76.5	76.5	76.4	76.8	76.2	76.5	76.8	75.8	77.5	76.5	76.9	77.3	75.9
current in galvanometer (in ampères)					1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0

remarks: period of exceptionally favourable, dry and warm weather between May 11th, 1947 and June 4th, 1947.

On June 11th, 1947 the animals 1 and 2 were placed together in the aquarium of No. 2; Nos. 5 and 6 were placed together in the aquarium of No. 6; 1 and 2 obtained six young on July 2nd; 5 and 7 obtained eight young on June 4th, 1947.

New period of exceptionally dry and warm weather started abt. June 15th, 1947, with gradually rising temperatures of up to 23.4° C.

On July 29th aquarium 2 placed at locality of aquarium 6, aquarium 6 at place of aquarium 2.

Dryden, John.
The Songs of John Dryden; ed. by
Cyrus Lawrence Day. Camb.,Harvard
Univ. Pr., 1932.
xvi, 199 p.

Although it was realized that, considering the small number of mice, no conclusive results could be obtained, we preferred to start these first experiments with a small number of mice. This enabled us to study each animal more individually and to observe the influence of external conditions which could be easily overlooked if a greater number of mice was used. Also the fact that the six white mice represented one litter and that the effect both on males and females could be studied, made this first experiment more conclusive than the small number of mice would otherwise allow. A complete report on these experiments will appear in the future but a few interesting results can be given now. In table I we have compiled only the results with the white mice, as these gave the most trustworthy experimental data. The column "magnetic deviation" indicates the deviation of an ordinary geological compass needle at the place of the aquarium, caused by the magnetic field of the tangent galvanometer. From this table and particularly from the complete weight, temperature and barometric curves during the 137 days of the experiment, a few interesting features can be deduced.

1. Up to May 11th, 1947 (i.e., during the first 50 days) during rather normal temperature conditions rising from 13.5° C to 16.5° C, the increase in weight both of the male (no. 5) and female (no. 6) outside the zone of disturbance was considerably larger than that of the mice in the field; not only was their total weight larger, but also the regular weekly increase. This is even more evident if the increase is expressed in percentages of the initial weight. Conditions of temperature, atmospheric pressure, food and light were the same for all 6 mice. Similar results were obtained with grey mice.

2. Whereas the weight curves of Nos. 5 and 6 rose more or less continuously during this first period, the curves of Nos. 1-4 were rather flat and No. 2 (being subjected to the strongest field) even showed a pronounced decrease in weight during the first week; a similar decrease, although very slight, occurred with Nos. 1 and 3.

3. From May 11th, 1947 to June 11th, 1947 the temperature in the cellar rose slowly from 16.5° C to 21.4° C (on June 4th, 1947). The temperature in the open air was very high at this period. During this period of 30 days we noticed a sudden change in the weight curves. The weight differences of Nos. 1-4 suddenly became 2 to 4 times larger than in the previous period, whereas the increase of Nos. 5 and 6 continued in the same gradual way. This difference is even more evident if the complete temperature and weight curves of this period are compared; these are almost perfectly parallel for Nos. 1 to 4.

4. A new period of exceptionally warm and dry weather started abt. June 15th, 1947, with temperatures above 20° C (after July 19th, 1947). Both Nos. 3 and 4 increased enormously in weight. The values of Nos. 1, 2, 5 and 6 are not trustworthy, however, they lived under changed conditions after June 11th, 1947 (Nos. 1 and 6 had to suckle 6 and 8 young respectively). It is interesting to note that even the males on August 5th,

1947 were decreased in weight, compared with their weight on June 11th.

5. The average increase in weight of the young of Nos. 1 and 2 amounted to 5.0 g/young in 35 days (July 2nd-August 5th), of the young of Nos. 5 and 6 abt. 3 g/young. Whether this difference is due to the different number of young in both cases or to differences in the mothers is difficult to say.

6. No relation appears to exist between the barometric curve and the weight curves.

7. In the period April 4th - May 8th, 1947 the average increase in weight of 4 young of two grey mice couples (Nos. 8 and 9) were compared: No. 9, living in a magnetic zone, had 7 young on April 17th, 1947; No. 8, living outside the zone, had 4 young on April 20th, 1947. On April 21st the weight per young was abt. the same for No. 9 and No. 8 (abt. 5 g). The increase in weight over 17 days amounted to 0.54 g/young/day in the case of No. 9; it amounted to 0.70 g/young/day for No. 8.

On May 26th, 1947 the young of No. 8 were separated from their parents. One female was placed in an aquarium above No. 2, one female young outside the magnetic zone. The increase in weight in the zone over 12 days (May 26th - June 7th) amounted to 0.17 g/day; outside the zone 0.29 g/day.

The cause of the increase in weight of the mice is partly due to actual growth. But with the male mice, Nos. 2 and 5, during the later period of development and after they had reached their maximal size, the increase in weight was mainly due to a considerable increase in the size of their testicles. With females (Nos. 3 and 4), particularly in the period July 19th-August 5th, 1947, the increase was mainly due to a swelling of the mammary glands. As this swelling is controlled by nervous action and chemical agents (particularly pituitary hormones) it seems that the particular conditions during the experiments stimulated both processes, either directly or indirectly.

Although the experiments are far from conclusive, they suggest that even weak, constant magnetic fields hamper the development of white mice under normal conditions of temperature; under conditions of high temperature the magnetic fields seem to have a stimulating effect. We have mentioned this reverse influence several times during the discussion of biological experiments. It is the famous *law of optimum activities* that dominates all biological processes and which makes all experiments with living material extremely complicated.

The growth experiments, which will have to be repeated with a great number of white mice, both with pulsating and interrupted constant fields, are of particular interest as they indicate the influence of disturbances (gradients) of the magnetic field of the earth on organisms that spend a considerable part of their life in these zones of magnetic disturbance. This, as we demonstrate in chapter III, shows up also as dowsing zones.

2. L. Experiments on the general influence of magnetic fields

SAITO placed rabbits between the poles of an electro-magnet that produced alternating magnetic fields with a frequency of 60/sec. During the first few minutes the animal did not appear to be influenced by the field, but after 8-10 minutes it became restless. The blood vessels began to swell, the tendons became reddish and moist, as a result of increased perspiration, and the animals became more and more depressed. Considerable contractions of the pupils were observed in similar experiments with rats. After these experiments, which lasted 15 minutes, the field was cut out and a few minutes afterwards the normal conditions were restored.

3. A. Experiments on pain-deadening influence

In about 1930, Dr K. M. HANSEN, of the Department B of the Rigshospital in Copenhagen, was struck by the fact that different kinds of pain often decreased if the pole of a horse-shoe magnet was pressed forcibly against the painful spot of the body. Between 1934 and 1938 she started systematic studies on the pain-deadening effect of constant magnetic fields and used electro-magnets with a lifting power of 8-14 kg. Either both the north and south pole were used, placed at opposite sides of the body, or two similar poles were placed on the same spot, or only one pole (mostly the south pole), this last arrangement being the most common. The patients never knew whether the current was switched on or off. Nonetheless, in these experiments, in contrast to the later discussed experiments of HANSEN, the influence of hypnotic suggestion was not excluded and might have been even very important. The treatment consisted of placing the magnetic pole above the painful part of the body for 2-15 minutes/day. This was repeated for two successive days, followed by a week's rest. Sometimes the painful spot was touched with the magnet or the nerve bundle was followed by the pole of the magnet. Although in several instances no improvement was obtained, there were never any contraindications to the treatment. Successful treatments are discussed in Bibl. No. 658, the most important being treatment of sciatica, headache, neurasthenics, lumbago, arthralgy, laryngitis, pharyngitis, cholecystitis, etc.

3. B. Experiments on influence on inflammations

HANSEN noticed favourable effects if inflammations of tendons, boils, bee-stings, etc., were treated with constant magnetic fields. With chronic gingivitis the bleeding of the gums stopped after 15 treatments, each lasting 15-40 minutes.

3. C. Experiments on oxygen absorption

In about 1902 MARAGLIANO and, independently of him, MÜLLER, discovered an increased oxy-hemoglobin content in blood if persons

were treated with magnetic fields. Dr HANSEN repeated these experiments in 1942 with a spirometer of KROGH. Altogether 208 patients were observed, giving a total of 559 metabolic curves. The patients were first observed for 8 minutes without a magnetic field and immediately afterwards the field was switched on for 5 minutes, without the knowlegde of the patient. The beds were all placed in the same direction and the south pole was always placed above the body.

The metabolic curves indicated:

1. oxygen absorption usually decreases in a magnetic field with nervous goitre patients;

2. it increases with normal people, the increase being greatest with nervous patients;

3. the best results are obtained if the tested persons follow a low protein and fat diet for 2 days prior to the experiment.

3. D. Experiments on the influence of magnetic fields on the general nervous condition of man

MÜLLER pointed out that alternating magnetic fields have a quiescent and sleep-provoking influence on man (see also p. 122, experiment of GRANDIS). This observation was supported by the experiments of SAITO (see above). He found a depressed condition after long treatment of animals, which might cause a quiescent effect on very excited persons.

BIRCHER, RODARI, ISCHEWSKY, FRANKENHAUSEN, and LILIENFELD suggested treatment with alternating magnetic fields in case of nervous diseases.

3. E. Experiments on the infuence of the magnetic field of the earth

We discussed on p. 94 the experiments of ALVAREZ. The relation between erythrocyte counts, etc., and the fluctuations of the magnetic field of the earth is probably not a direct relationship, but seems to be due to the relationship between the magnetic field of the earth and the electric field in the atmosphere (see p. 231).

The author (see p. 304) pointed out that considerable gradients in the earth magnetic field, particularly if a person spends a considerable part of his life in such a gradient zone, might influence the health of that person. The above-mentioned experiments appear to support this assumption.

4. A. 1. Experiments on growth of bacteria

LEUSDEN tested the influence of magnetic fields on *bacterium coli* and *staphylococcus*. Neither alternating fields nor constant magnetic fields had any influence on the growth of those organisms.

LENZI repeated these experiments with *bacillus pyocyaneus*. He often

observed a decrease in growing speed in alternating fields with frequencies of 42/sec.

SUMMERS and HUGHES also studied the influence of alternating fields, but they used *colpidium campylum*. The reasons for this preference was that Colpidium is an easily cultivated free-living type, small enough to become adjusted readily to temperature variations.

SUMMER measured the mean daily division rate of 129 individuals of Colpidium. Individuals were placed in minute capillaries in which cooling is inversely proportional to the radius. This prevented the temperature factor from assuming importance. The capillaries with bacteria were treated with homogeneous and non-homogeneous alternating magnetic fields with field strength of 1.9-5.7 Gauss. The differences observed in the production of new generations in 48 hours, between controls and treated bacteria, were very small. Only those series exposed

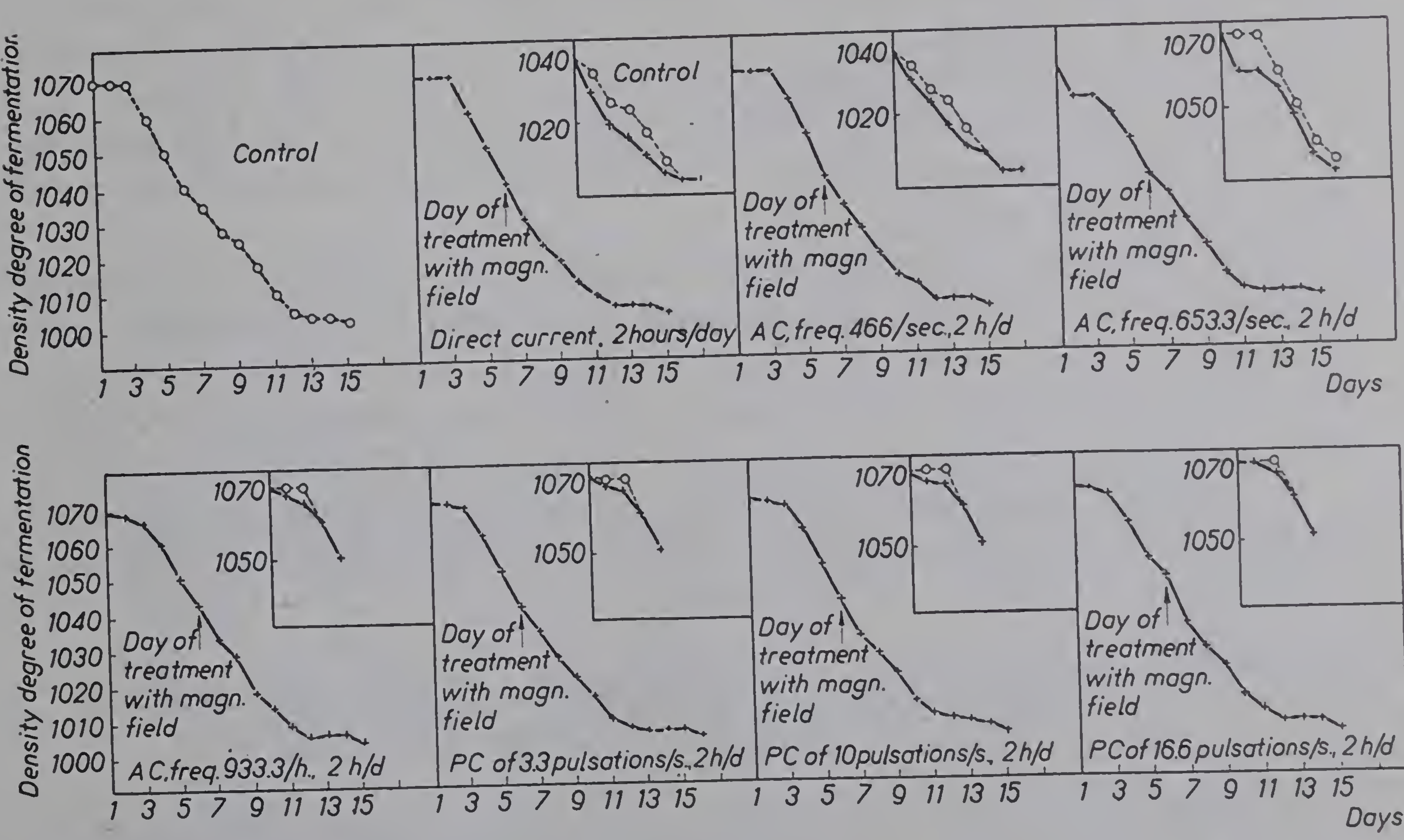

Fig. 83: (Bibl. No. 671, p. 225) Diagram showing the relationship between the fermentation capacity of Saccharomyces Cerevisiae and alternating magnetic fields. Curves indicate mostly decreasing fermentation with alternating fields, the decrease being greatest at low and medium frequencies; pulsating fields giving the same results.

to 60 Mega-cycles showed a slight increased division rate. However, it is not excluded that *Hertzian* waves (see p. 65) are responsible for this increase. This applies in general to many of the experiments with alternating magnetic fields.

4. A. 2. Experiments on the mobility of bacteria

CHEMEVEAU and BOHN studied the influence of an electro-magnet with polar distances of 1.5 cm and a field strength of 5,000-8,000 Gauss on Protozoa in glass capillaries which were open on one side. With *loxophyllum* the velocity decreased after the 2nd day from 400 μ/sec to 134 μ and after 4 days to 80 μ/sec. The decrease in mobility was observed first at the Cilia. With Colpidium Colpoda, it was found that after 5 days the velocity was reduced to 1/5 of its original value. The size of the newly developed generations decreases; according to CHEMEVEAU and BOHN it is first 70-80 μ and in later generations 30-40 μ. Other Protozoa showed the same phenomena. FRANCIS, in the Botanical Laboratory at Brisbane (Australia), observed that the settling speed of iron bacteria, *leptothrix ochracea*, is retarded by a horseshoe-magnet.

4. B. Experiments on the influence on moulds

LENZI studied the influence of alternating magnetic fields on the fermentation capacity of *saccharomyces cerevisiae* (see fig. 83). The fermentation generally decreases, the minimal at low and medium frequencies. Constant magnetic fields appear to influence the fermentation (see fig. 83, 2nd diagram of upper row); this had been previously observed by PIROVANO in 1935.

This brings us to the end of the section on the influence of external magnetic fields on living organisms. A great number of phenomena have been reported, the causes of which are only partly known. The biomagnetic effect is generally different in constant, alternating and pulsating magnetic fields. In most experiments only one of these types of fields was studied.

A considerable number of problems still lie ahead for the experimental biologist. The solution of them might prove to be of great importance to the medical sciences of the future.

PART IV: INFLUENCE OF ELECTRO-MAGNETIC WAVES
(see Bibl. No. 181a-213, 351-361, 687, 688)

The influence varies considerably with the wavelength. It is therefore apt to discuss the different biological experiments in accordance with the classification of wavelengths (see p. 62):

1. *γ-rays* ($\lambda = 0.003 - 0.01$ mμ):

   The influence on man is too well known to be discussed in this publication. We discussed on p. 100 the phenomenon of *radiotropism* of plants.

2. *X-rays* ($\lambda = 0.01 - 1.0$ mμ):

   The effect of Roentgen-rays also is well known and needs no special reference here (see Bibl. No. 687 and p. 64, 67, 73).

3. *Ultraviolet rays* ($\lambda = 1.0 - 390$ mμ):

On p. 64 we discussed the HALLWACH effect and the ejection of electrons present in organic tissues, on p. 66 the influence of the absorption coefficient and on p. 71 - 73 the mechanism of the biological effects. Ultraviolet rays also possess more important biological effects. In Bibl. No. 207 an excellent survey is given of the genetical effects of ultraviolet rays on the fly Drosophila, on maize, Antirrhinum and some lower plants, as a result of the production of structural changes in the chromosomes (see also p. 67). These permanent changes, due to irradiation, create *mutations* and were studied by FETSCHER, HERTWIG, MÜLLER a.o., about 1925. These evolutional jumps are probably closely related to the phenomenon of energy quanta of PLANCK.

4. *Visible light* ($\lambda = 390 - 770$ mμ):

The direct visible effect of ordinary light on living organisms is demonstrated best on plants. On p. 98 we dealt with the phenomenon of *phototaxis* and *phototropism*; on p. 100 of *photonastics* and *nyktinastics*.

5. *Infrared* ($\lambda = 770$ mμ - 220 μ):

The influence on the human body has been discussed on p. 71 (heat-hyperemia) and p. 117 - 120. The influence on plants was described on p. 100 as *thermo-nastics* and *thermo-tropism*.

6. *High frequency Hertzian waves* ($\lambda =$ few mm - few hundred m):

The causes of the influence of Hertzian waves on electrolytes and living organisms in general has been commented upon on p. 65 and 68. A few experiments on the influence on bacteria, animals and man should be mentioned here.

A. In Bibl. No. 191a and 212 the destructive influence of ultra-short Hertzian waves ($\lambda < 10$ m) on *bacteria* is discussed. The influence seems to be mainly a thermal effect. In 1924 GOSSET, GUTMAN, and LAKHOVSKY grafted bacterium tumefaciens on geraniums. This caused the development of tumours on those plants which disappeared after irradiation with Hertzian waves of 2 m wavelength (see Bibl. No. 688).

B. SCHERESCHEFSKY and SCHLIEPHAKE (Bibl. No. 688, p. 89) found that mice die within a few hours when irradiated by a strong bundle of ultra-short Hertzian waves. Flies died in a strong condenser field. Small mammalia bled at the paws, gums, etc. Particularly extremities of the body, such as ears, tail, fingertips are very sensitive to Hertzian waves. JELLINEK (Bibl. No. 688, p. 90) found that the embryos of parrot eggs, irradiated for a fortnight with Hertzian waves with a frequency of 10^8 Hz, developed more rapidly than the non-irradiated eggs.

C. It has been known for some time that ultra-short wave transmitters cause disturbances in men working in front of them; whereas several hours' irradiation is noticed by certain people only after a few days, others react almost immediately and can tell whether short waves are present without knowing whether the transmitter is working or not (see Bibl. No. 688, p. 86). The head seems to be the most sensitive part.

The Hertzian phenomena in man are the following: fatigue, which might change into apathy; with continuing irradiation nervousness and restlessness, feeling of alarm, pessimism, a tendency to insomnia, and broken sleep. In the morning after he arises, he feels depressed and inert. Serious headaches develop if the treatment is continued. The phenomena greatly depend upon the wavelength used. Waves larger than 10 m are rather harmless, but below 10 m the influence increases with decreaing wavelength. The complaints generally disappear rather rapidly after 6-8 days if the treatment is interrupted, unless the original treatment lasted too long.

In an ordinary transmitter is not used but the trial person is placed in a condenser field, the disturbances are more characterized by intense drowsiness; people with a great sense of touch observe a fine vibration in the fingertips.

7. *Cosmic rays* (see p. 63):

Dr Figge (Bibl. No. 635), from the Medical Faculty of the University of Maryland (U.S.A.), made some interesting experiments in about 1946 on the influence of cosmic rays on cancer. 148 male mice were injected with 0.25 mg methylcholanthrene in sesamoil and developed carcinoma. The mice were equally distributed in 8 aluminium cages 11 · 11 · 4 inches. Leadplates $^1/_4''$ thick were placed over 5 out of 8 cages, about 3 inches above the mice. When cosmic rays pass through thin sheets of metal they produce shower bursts of ionizing radiations, which intensify the influence of cosmic radiation. The optimum thickness for production of small cosmic radiation showers was found to be 0.6 cm, for large showers 2 cm. 4 of the cages were covered with a lead plate 0.6 cm in thickness, the other, with two lead plates. The cages were placed on different floors of a concrete steel building. Figge found that mice exposed most to the effect of cosmic radiation developed the greatest number of tumours. After 10 weeks, of the 111 injected mice still alive and exposed to increased cosmic radiations, 84 had taken carcinoma, whereas with 67 mice, exposed to cosmic radiation in a normal way, only 22 had taken cancer.

The experiments of Figge are not yet conclusive, as only a relatively small number of mice were studied. It is also uncertain whether the observed phenomena are really due to cosmic radiation or to

differences in potential gradient and different electro-static potential differences in lead-covered and non-covered cages.

This short review of the influence of electro-magnetic waves on living organisms indicates their importance for the study of divining phenomena.

PART V: SUMMARY OF GEOLOGICAL AND GEOPHYSICAL FACTORS INFLUENCING LIVING ORGANISMS

The preceding chapters have shown that organic life is continuously subjected to external forces due either to the geophysical or the meteorological field of the earth, both being the result of terrestrial and extra-terrestrial forces. We have seen that in many instances both influences are so interwoven that it is difficult to differentiate between them. The main external factors that influence living organisms can be divided into two groups, one closely connected to the earth crust itself (lithospheric factors) and the other related to the atmosphere (atmospheric factors). These different factors can be summarized as follows:

1. Main lithospheric factors

A. Geological factors

1. *Soil factor:*
   a. influence on mineral composition (influencing acidity of the soil, kind of vegetation, etc).
   b. influence on micro-organisms
   c. influence on soil structure (determining the porosity, cleavage, permeability, etc., which directly influences groundwater level, amount of evaporation, earth-gas content, etc., and indirectly the kind of vegetation and animal life consuming this vegetation)
   d. soil relief (influencing ground-water level, etc.)
   e. influence on geophysical factors
2. *Topographic factor:*
   a. direct influence on climate (temperature, atmospheric pressure, humidity, etc.)
   b. indirect influence (determining the distribution of land and sea, origin and distribution of sea-currents, etc.)
3. *Earthquakes:* destructive factor
4. *Volcanic eruptions:*
   a. influence on fertility of soil
   b. destructive influence
   c. increased CO_2 (influencing the absorption of the sun's rays, see p. 69)
   d. increase of dust particles (influencing ionization, precipitation, etc.)

B. Geophysical factors

1. *Magnetic factor:*
   a. direct influence of magnetic gradients (determined by geological and cosmic factors)
   b. indirect influence (creating variations of the earth potentials)

2. *Electric factor:*
   a. influence of electric earth currents (determined by geological and atmospheric factors)
   b. influence of equipotential surfaces (determined by geological and atmospheric factors)
   Both influencing potential gradient and ionization of the atmosphere

3. *Radioactive factor:* influence on ionization (determined by geological and atmospheric factors)

4. *Geochemical factor:* (determined by geological and atmospheric factors)

5. *Geothermal factor:* influences on the electric factor (determined by geological factors)

2 Main atmospheric factors

1. *Temperature, humidity, barometric pressure* (influencing wind-factor ionization, etc.)

2. *Electric field*
   a. influence of potential gradient (determined by cosmic, geophysical and geological factors)
   b. influence of ionization (variation in sign and number of ions per cm^3)

3. *Electro-magnetic field:*
   a. ultraviolet radiation
   b. visible light radiation
   c. infrared radiation
   d. cosmic rays

This brief summary brings us to the end of chapter II. We have seen that external forces in man can create unconscious impulses which are continuously reflected in a most complicated way in the physiological processes in the body and in the actions controlled by the central and sympathetic nervous systems. The unconsciousness of these processes is the most important feature. It shows that we are continuously subjected to forces which we do not observe consciously, forces which are also responsible for the divining phenomena which we discuss in the following chapter.

It has taken many centuries of scientific research before man was

inclined to accept the existence of these external, not directly noticeable, forces. We hope that, with the evidence given in chapter III, it might not take long before scientists will accept the reality of divining phenomena and are willing to devote their time to the solution of these problems. These are not only of academical interest, but are bound to influence greatly the development of medical and natural sciences.

CHAPTER III

DIVINING AND KINDRED PHENOMENA

Before we start the discussion on the different divining phenomena it will be necessary to give a more precise definition of *divining*. It has been used with different meanings, but there is rarely a clear scientific definition that indicates the group of phenomena which belong to divining. The verb "to divine" means the capacity to predict certain processes or phenomena in the non-perceptible world around man. This capacity has been ascribed to a heavenly (i.e., divine) gift of only a few favoured human beings.

The *neo-vitalists*, in particular DRIESCH, believe in an immaterial factor in life called *entelechy*, after ARISTOTLE, a principle that bears the aim of its action in itself. To them "divining" means something supernatural, ruled by non-physical laws.

The *neo-materialists* (see Bibl. No. 1448) however, reject this assumption. Prof. H. J. JORDAN criticized the neo-vitalists by saying: "It is dangerous and misleading to create a word instead of mentioning the problem, as it gives that word the impression of being a force, which as a supernatural cause would create everything which in fact could be understood as a product of a harmonic complex of different causes which could be analysed."

We have observed in previous chapters that a most complicated "divine" web of electro-magnetic forces in the non-perceptible world surrounding us appears continuously to regulate a great many of the mental and ordinary physiological processes in our body. Psychic and ordinary physiological processes are only gradations, not qualitatively different but quantitatively. Both represent the most complex physical phenomena in the world of organic compounds, similar to the ordinary crystals being the highest form of physical processes in the inorganic world.

We should like to define *the divining phenomena as the group of the most complex physico-chemical phenomena occurring in the world surrounding living matter and unconsciously perceptible* by nearly every body (not only a favoured few).

After being registered by our nervous systems they can be amplified and transformed into phenomena known in the ordinary perceptible world. In other words, divining comprises those phenomena that

usually need a biological amplifier for conscious observation with the ordinary sense organs. This explains why it is not everyone who can consciously observe the divining phenomena.

Using this definition, practically all para-psychological phenomena belong to the divining phenomena. In view of the purpose of this publication we must restrict ourselves only to those phenomena that have been always considered as belonging to divining even by the neo-vitalists. For this reason we divide this last chapter into 5 parts. In part I we discuss the phenomena of *water divining*, better known as *dowsing* or *rhabdomancy*; in part II *radiesthesia*. The distinction between radiesthesia and dowsing is not very clear. Many authors consider dowsing as a part of radiesthesia, others consider it as two separate groups of phenomena. In both groups the divining rod and the pendulum is used, but whereas in dowsing the main object is the study of non-living objects, particularly the study of underground conditions by means of an ordinary divining rod, radiesthesia sensu stricto is mainly interested in the study of living matter by the use of pendulums and samples of diseased tissues, bacteria, etc., which should enable the radiesthesist to diagnose the cause of diseases and to estimate the suitability of remedies and dosage in treatment. As the radiesthesists believe in radiations as being the main cause of this capacity, this group of phenomena became known as radiesthesia (see p. 364).

As the word radiesthesia has been generally adopted by all laymen interested in divining we concur with common usage, though we do not accept the explanation. We would suggest the name *pallomancy* (from the greek word pallo = to pendle and manteia = divination) for the study of divining phenomena with pendulums.

Because of the vague distinction between rhabdomancy and pallomancy in the bibliographical list we combined both groups of phenomena under one heading. For scientific purposes, however, it will be necessary to restrict *rhabdomancy to real divining rod phenomena*, *radiesthesia* (or pallomancy) *only to pendulum phenomena*. Both together could be combined in the group of *muscular-divining phenomena*, as the arm muscles are used as indicators for internal psychic or ordinary physiological changes.

We discuss in part III the *magnetizer phenomena*, also known under the more modern name of *hypnotic phenomena*.

In part IV the *sensitivity for direction of animals* is briefly mentioned.

Finally, in part V we give a review of the possible applications of the previous analyses on other para-psychological problems and we urge the necessity for establishing special laboratories for *psychical physics*, a new, probably most far-reaching branch of future physical sciences.

It is evident that a complete discussion of each of these parts would require several thousand pages of print. Objection might be raised in that the previous chapters have been shortened for the benefit of this last chapter. However, as mentioned previously the *science of divining*, or better called *psychical physics*, requires a solid basis and it is this basis

which was lacking. Only with a solid foundation can we climb the steep pyramid of divining. In the more than 1,000 publications on divining we can find an overwhelming number of facts, partly true, partly fantastically imaginative. Scientific proof of the reality of all the phenomena may take years of intensive scientific research. It therefore seems unnecessary to give a complete review of all the reported so-called facts. It is the basis required for the study of those facts which is more important than the facts themselves and it is in this light that this publication must be viewed. It does not intend to discuss the science of divining phenomena as a whole but only the basis and the first steps of the pyramid. The foundation has been laid in chapters I and II; let us now climb the first steps of the pyramid.

PART I: RHABDOMANCY

(see Bibl. No. 689-1378)

1. Historical review and bibliography

Bibliography:

In bibliography Nos. 689-1378 we have compiled abt. 700 publications on dowsing and radiesthesia known to the author directly or indirectly. Although we fully realize that this list is far from complete, it gives a fairly good idea of the amount of interest the problem of dowsing has aroused in past centuries. In fact it is doubtful whether so much investigation and discussion have been bestowed on any other subject with such lack of positive evidence for the reality of the observed facts.

In bibliography Nos. 689-1378 the most important publications are marked with a star; those authors who did not believe in dowsing are indicated with a capital A. Extensive bibliographical lists can also be found in Bibl. No. 726, 763, 873, 1033, 1034 and 1287.

Countries of dowsing origin:

The origin of the divining rod is not known, although vague references in history indicate that the divining rod has been in use almost as long as civilisation has existed, i.e., abt. 7,000 years. They were used for forecasting events, searching for lost objects and in occult practices.

LATIMER (Bibl. No. 1072) pointed out that several passages in the bible suggest the use of divining rods in olden times. First of all the passage about the "smiting of the rock" in the books of Moses; in "Hosea IV, 12" we find the passage "My people ask council at their stocks and their staff declareth unto them"; in "Ezekiel XXI, 21" is written "The King of Babylon stood at the parting of the way, at the head of two ways, to use divination; he made his arrows bright."

RAYMOND (Bibl. No. 1205) mentioned passages in HERODOTUS, descriptions which indicated that the rod was used by Scythians, Persians and Medes. The word *rhabdomancy* originated from the Greeks; it derived

from the words *rhabdos* = rod and *manteia* = divination and meant the practice of searching for springs, well sites, precious metals, etc., concealed in the earth. RAYMOND also referred to the rods of Minerva, Circe and Hermes, which according to the Greeks had magical power.

The *lituus* of the Romans, with which the augurs divined, was apparently an arched rod.

MARCO POLO reported the use of the rod throughout the Orient. TACITUS had it that the ancient Germans used branches of fruit trees as divining rods. According to GONSALEZ DE MENDOSA, the old Chinese also used the divining rod.

In all these references it seems that the rod was mainly employed for detecting guilt, deciding future events, etc., and not so much for the discovery of metals. It is remarkable in this respect that neither VITRUVIUS nor PLINY, discussing extensively the means of discovering springs, mentioned the rod.

First publications and reproductions:

The first published description was found in GEORGIUS AGRICOLA'S "De re metallica" (Bibl. No. 691), begun abt. 1533 and published in 1556. It was translated into English by H. C. and L. H. HOOVER and published by the Mining Magazine, London, 1912. AGRICOLA condemned the use of a divining rod as a superstitious and vain practice.

In the Journal of the British Society of Dowsers of March 1946, a photograph was reproduced of a cast exhibited in the National Museum in Aleppo, which was collected by Mr L. J. LATHAM. The cast was excavated by BARON MAX VON OPPENHEIM in 1911 at Tell Halaf, Mesopotamia, in layers containing objects from the Mitannia-Hittite Kingdom, dated abt. 1300 B.C. The cast represents a priest who holds between his hands a tapering object which could be a kind of divining rod. If the interpretation is correct this would be the oldest reproduction of a divining rod. According to KLINCKOWSTROEM (Bibl. No. 1036a) the oldest reproduction of a dowser dates from 1420 (found in a manuscript at the Hofmuseum, Vienna, No. codex 5014).

Two other publications might be older than "De re metallica". One of the accounts is contained in Bibl. No. 727 and was written by BASILIUS VALENTINUS, a Benedictine monk of the 15th century, who devoted seven chapters of the second book of this work to a didactic account of the use of the divining rod. However, there is some confusion on the date and authorship. BASILIUS lived at Erfurt in St. Peter's convent in 1413, but the earliest known copy of his book is a French translation, dated 1651.

Another old account is a publication by PARACELSUS (Bibl. No. 1174a), date unknown. As PARACELSUS died in 1541, this work is probably older than "De re metallica", although it was published later. PARACELSUS came to the following conclusion (translation by H.C. and L.H. HOOVER in 1912): "Divinations are vain and misleading and among the first

of them are divining rods, which have deceived many miners. If they once point rightly they deceive ten or twenty times."

Possible source of the use of divining rods:

According to BARRETT (Bibl. No. 723) the birthplace of the modern divining rod must be sought in Germany, probably in the Harz district. He gave also an explanation of the possible source of the use of a divining rod. In olden times people believed that metallic ores attracted certain trees which drooped their branches over the place where ores were to be found. A branch was cut from the tree and held in the hands to see whether it would droop; forked branches were used for convenience.

Divining in the period of religious persecution (16th and first half of the 17th century):

During the reign of Queen Elisabeth (1558-1603) German miners were imported into England to lend impetus to the industry in Cornwall. They probably introduced the divining rod into England. At the end of the 17th century it spread all over Europe and aroused great controversy amongst scientists. A great number of the opponents of dowsers, such as AGRICOLA, adopted their attitude, not for scientific reasons, but because they associated dowsing with satanic practices. This belief partly resulted from the fact that most dowsers in the Middle Ages surrounded their practices with ceremonies and formulae of highly pious character. The following formula cited by GAETZSCHMANN (Bibl. No. 923) may serve as an example: "In the name of the Father and of the Son and of the Holy Ghost, I adjure thee, Augusta Carolina, that thou tell me, so pure and true as Mary the Virgin was, who bore our Lord Jesus Christ, how many fathoms is it from here to the ore?"

Theory of attraction:

The believers in divining explained dowsing on the principle of "sympathy" or "attraction and repulsion". The then recently discovered phenomena of magnetism and gravity supported this interpretation. They were forced to surround their practices with a religious atmosphere, as in those times anyone found engaged in mysterious works was in danger of being charged with sorcery and being burned to death.

One of the leading characters in the 17th century was BARON DE BEAUSOLEIL (JEAN-JACQUES DE CHATELET, 1576-1643; see Bibl. No. 749, 750 and 751) one of the foremost authorities on mining; he travelled all over Europe and America. Because of his use of divining rods he was, charged with sorcery and imprisoned in 1642, where he died shortly afterwards.

In Bibl. No. 751 Baroness DE BEAUSOLEIL gives a description of the five methods used by her and her husband for the discovery of ore deposits:

1. digging;
2. herbs and plants which grow above streams of water;

3. taste of waters that flow from ore deposits;
4. vapours that arise above ore deposits at sunrise;
5. the use of 16 scientific instruments and the 7 rods of BASILIUS VALENTINUS (see Bibl. No. 727) connected with the 7 planets which we mention above.

Gradually the divining rod was used more and more for water-divining and less for the discovery of ore deposits.

Beginning of the period of enlightment (end of the 17th century)

A new development in the history of dowsing started about 1659 after the publication of a book (Bibl. No. 1260) by the Jesuit Father GASPARD SCHOTT, who denounced dowsing as a method controlled by the devil. For more than a century it was hotly debated by churchmen. Some approved of it, others threatened the dowsers with excommunication. SCHOTT later revised his ideas as monks of great piety had been using rods, apparently with great success. Both he and KIRCHER (Bibl. No. 1023 and 1024) were the first to advance *the theory that the movement of the rod is due to unconscious muscular action.*

In 1673 JACQUES DE ROYER (Bibl. No. 1089) announced for the first time that the *material of which the rod is made is of little importance.* The same results could be obtained with wood, oxhorn, ivory, gold or silver

Divining rod used for criminal investigation:

In 1692 an incident occurred in the south of France that added greatly to the notoriety of the divining rod (see Bibl. No. 721, p. 54 and 1118, p. 362-365). This incident was the arrest and identification of a criminal through the agency of a peasant of Dauphiny, named JACQUES AYMAR, who claimed the ability to trace fugitives by the use of divining rods. AYMAR soon became notorious throughout Europe.

In 1701 the Holy Inquisition issued a decree against the further use of divining rods in criminal prosecution, as it was considered still to be an instrument invented by Satan.

Electrical theories (18th century)

In about 1692 PIERRE LEBRUN (Bibl. No. 1076) suggested his *theory of prior intention.* Up to 1780 this was generally accepted by the Church. The new discoveries of electric phenomena and the discovery of action currents during muscular contraction by GALVANI in 1786 started a new era in the history of divining.

PIERRE THOUVENEL (Bibl. No. 1301) developed the *first electrical theory* (see also Bibl. No. 702) about 1780. THOUVENEL was physician to Louis XVI and was interested in another peasant of Dauphiny, BARTHÉLÉMY BLETON, a herdsman brought up in a monastery. This boy showed *hydroscopic faculties.* When a boy of 7 he was taking food to some workmen; after he sat down on a stone he suddenly felt faint. When the workmen carried him away from the stone the faintness ceased,

but each time he returned to it he felt faint again. The prior of Chartreuse was interested in the case and had the ground under the stone dug up; a spring was discovered which is still in use in present time. THOUVENEL was also interested and tested the boy for many years. The results of his studies are compiled in Bibl. No. 1301-1307. The main observations with BLETON were the following:

1. he was only sensitive to running water;
2. neither the form nor the material of the rod were important, the rod merely acting as an indicator for his inward feelings;
3. his sensitivity decreased when he was on a tree, a ladder or on another person's shoulders or when he touched electrified substances; the movements stopped completely when he was insulated from the ground. This latter phenomenon was confirmed later by LATIMER (Bibl. No. 1072), who claimed that when a dowser was placed on a platform supported by glass bottles, he lost all sensitivity;
4. he was able to follow a subterranean aqueduct in the garden of the Luxembourg for 15,000 yards; however when blindfolded he often passed running water without noticing it; taken several times over the same course he would not point accurately each time to the spot he had previously marked;
5. Dr CHARLES took occasion, while BLETON stood on the insulated stool, to connect the top, without BLETON knowing it, to the earth. The insulation effect continued. This was declared as a proof of BLETON's charlatanry;
6. BLETON was blindfolded and led into a new church with foundations extending 30 ft below the floor. At several points running water was indicated, where it was known that none existed. This was further proof for anti-diviners such as RAYMOND (Bibl. No. 1205) and ELLIS (Bibl. No. 873). In the following pages we demonstrate how dangerous and precipitant these conclusions were.

In addition to BLETON, PARANGUE and PENNET in the Dauphiny and CAMPETTI in Italy proved to be notorious dowsers of the 18th century.

Introduction of the pendulum:

In the beginning of the 19th century another type of divining rod was introduced (used previously during magic experiments), the so-called *magic pendulum*, which is discussed more extensively on p. 369. It consisted of a finger ring or piece of metal, etc., attached to the end of a cord and suspended from the hand. In the beginning of the 18th century it was used for locating well sites (see also p. 369).

Scientific studies in the 19th century:

In 1812 MICHEL EUGÈNE CHEVREUL made an investigation into the subject (Bibl. No. 811 and 812) on behalf of the Academy of Science in 1854 and concluded that the whole phenomenon was the result of involuntary muscular movements in the hand, induced by mental processes.

Michael Faraday in 1854 explained *table turnings* during spiritualistic seances in a similar manner.

At the end of the 19th century several important studies on the divining rod appeared.

In about 1875, Charles Latimer (Bibl. No. 1072) in the U.S.A. concluded that the movements of the rods depended on electric currents transmitted from the ground through the body, thus inducing a magnetic field between the rod and the ground.

In 1891 W. F. Barrett (Bibl. No. 722), Professor of Physics at the Royal College of Science in Ireland, undertook a very laborious investigation on dowsing in the interest of the Society for Psychical Research in London. Barrett came to the following conclusion: "the movements of the rod or forked twig is due to unconscious muscular action arising from subconscious and involuntary suggestion impressed on the mind of the dowser, and this subconscious suggestion may be merely an autosuggestion or a suggestion derived through the senses from the environment, but in a certain number of cases it appears to be due to a subconscious perceptive power commonly called clairvoyance."

Scientific studies in the 20th century:

Between 1909 and 1934 a series of publications were written by Henri Mager (Bibl. No. 1113-1124); he tried to explain the divining phenomena with the latest physical discoveries on radioactivity and electro-magnetic waves.

His studies were continued and extended by the more scientific methods of Franklin and Maby (Bibl. No. 1111) which started between 1930 and 1935 and which developed into a *biophysical laboratory* at Bourton-on-the-Hill (Moreton-in-Marsh, Glos., England). His studies, which have been continued up to recently, forced Maby to the conclusion that the dowsing phenomena are the result of direct or indirect influence of Hertzian waves. We shall discuss his views at greater length later on.

In recent years, particularly in Holland, the *earth-ray theory* has again come to the fore, particularly because of the publications and lectures of Mieremet and others. Mieremet proposed the use of certain instruments which could eliminate the earth-ray effect. Although gifted with dowsing capacities, Mieremet has fallen a victim to his own theories, which suffer from a lack of physical knowledge and he cannot be looked upon as a serious research worker on dowsing. The interpretation given by dowsers of this type are bound to be wrong and do a lot of harm to the scientific development of divining.

Artificial divining instruments:

A great number of primitive instruments has been divised by dowsers, either to detect ores or water springs or to prevent the biological influence of these disturbing underground forces. They are based mainly on magnetic or electric phenomena (see Bibl. No. 1052). Amongst the widely

advertised instruments we can mention the *phonendoscope* (Bibl. No. 1045); *hydroscope*; *hydrotachymeter*; W. MANSFIELD's "*patent automatic water and oil finders*" (Bibl. No. 1139); HENRI MAGER's "*indicateurs d'eaux souterraines en mouvement*" (Bibl. No. 1114); ADOLF SCHMID's "*device for detecting subterranean waters*"; "*the earth-ray*" *apparatus* of MIERMEIT (Bibl. No. 1143), a.o. In fact all these instruments are either completely worthless or poor imitations of geophysical instruments (see p. 217 and 232). We shall return to this problem later on.

2. Types of divining rods

Since the first divining rods were described by AGRICOLA (Bibl. No. 691) and VALENTINUS (Bibl. No. 727) a great number of different divining rods have been used of which the most important types are represented in figs 84-91. Two main types can be distinguished: a *loop-shaped wire*

Fig. 84: (Bibl. No. 873, fig. 1) Ordinary type of a wooden, forked divining rod held in the usual manner.

Fig. 85: (Bibl. No. 873, fig. 2) Same type of divining rod as fig. 84, but held in a less common manner.

(fig. 86) and a *forked type* (fig. 84), the latter being the oldest type of rod. They are made of different materials: wood (a twig of a tree), metal wire, whale baleen, oxhorn, ivory, etc., irrespective of whether they are conducting and non-conducting materials. The kind of wood of which

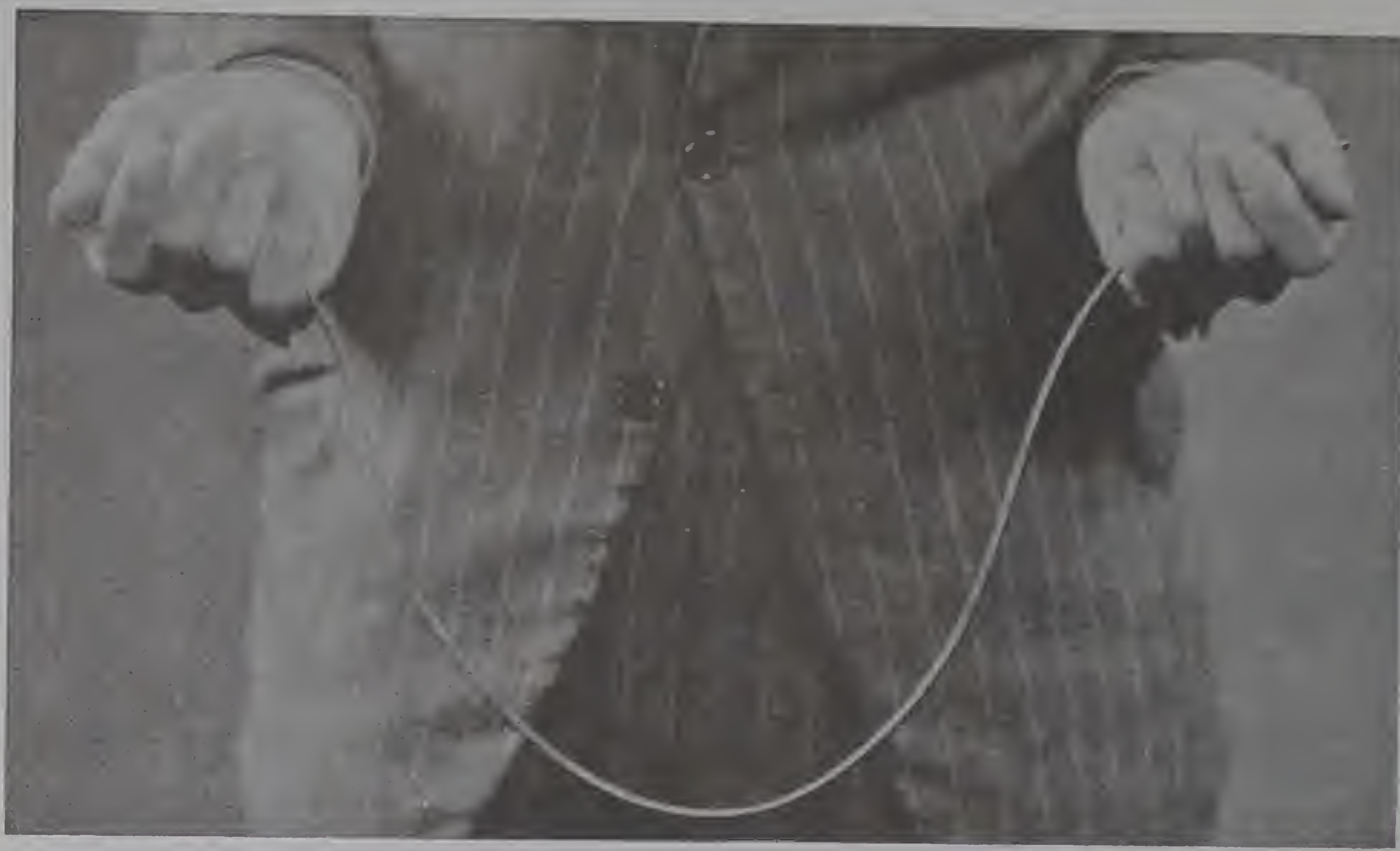

Fig. 86: Loop-shaped divining rod made of elastic metal wire held in under-grip.

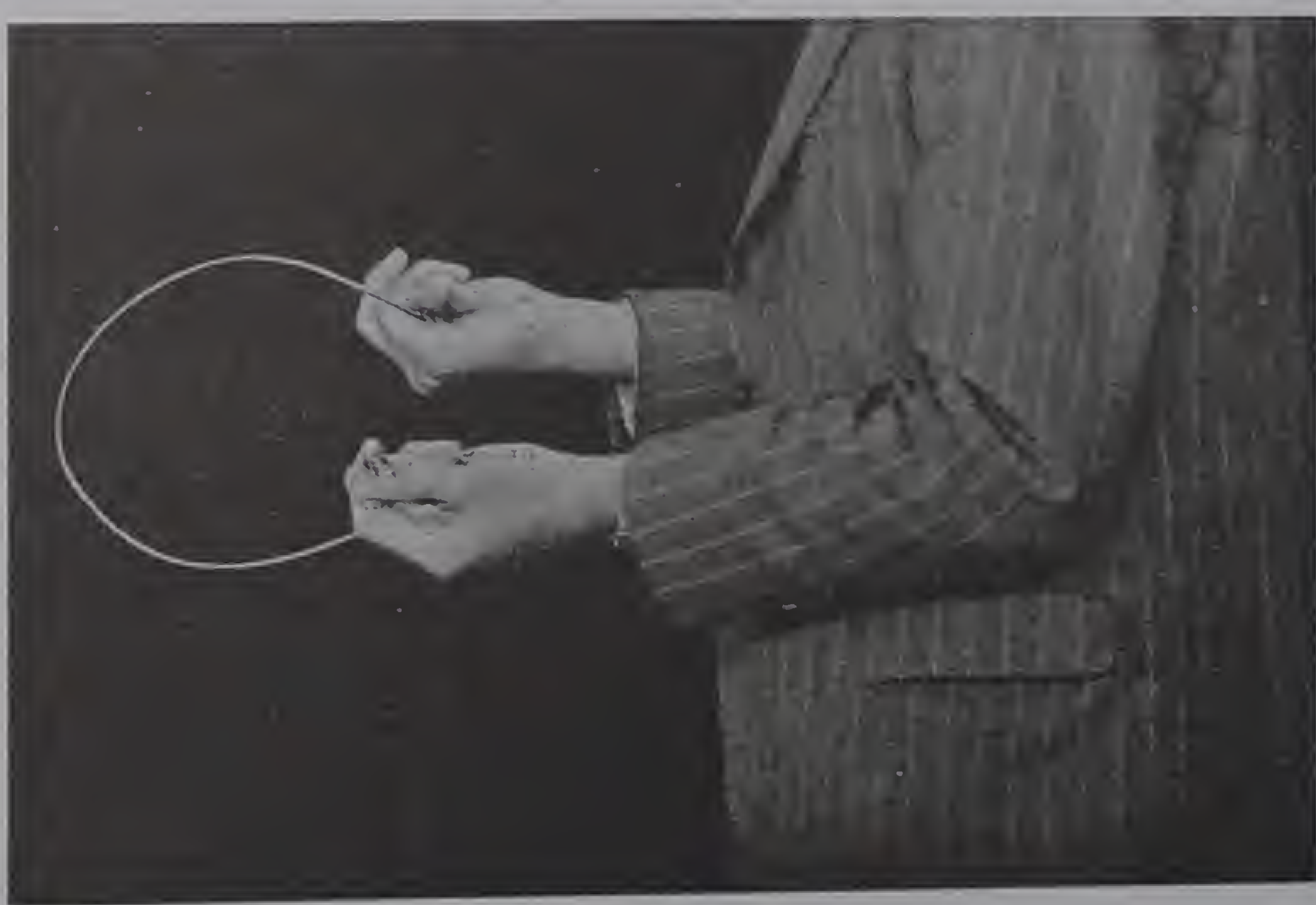

Fig. 87: Same type of divining rod as in fig. 86, showing rod in turned position, right hand side coming up.

the twig should be made has differed at different times and places, but peach, willow, hazel and witchhazel were generally favorites. As we mentioned on p. 292, Jacques de Royer (Bibl. No. 1089) was the first to state officially that the material of which the rod is made is of little importance.

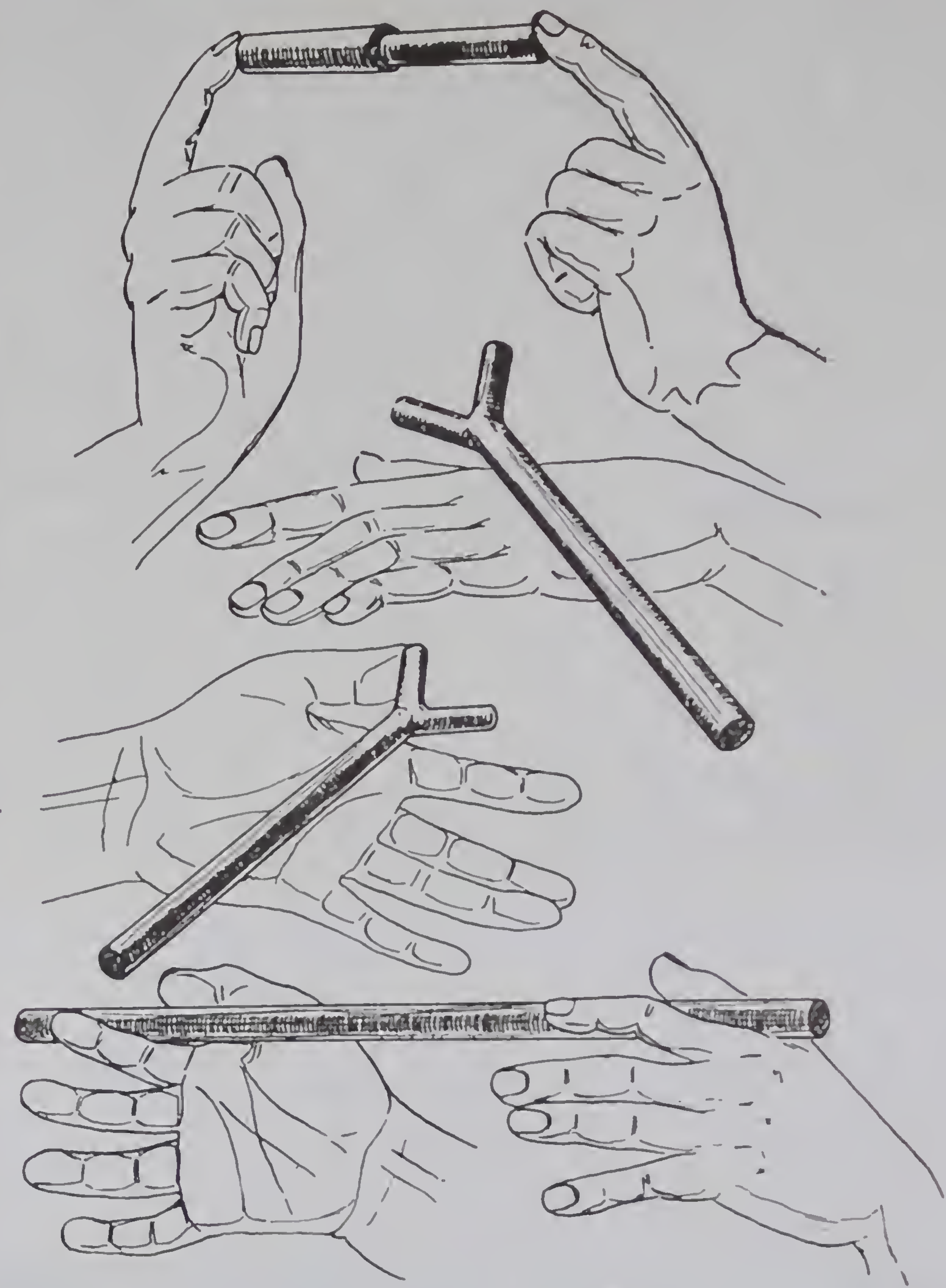

Fig. 88: (Bibl. No. 1321) Various old types of divining rods and the manner in which they were held.

Different names have been given to the divining rod in different countries: in *England* it has been described as *divining rod* and *conjurers wand*, the person using the rod being known as *waterwitch*, in recent times only as *dowser*. In *Germany* it is known as *Wünschelrute*, *Zauber-rute*, *Siderischer Pendel*; the diviner is called *Rutengänger*, *Wassermuter* and *Wasserschmecker*. In *Switzerland* the name *Rütlimänner* is also in use. In *France* the names *baguette*, *baguette divinatoire*, are commonly used, the diviner being called *baguettiste*, *baguettisant*, *sourcier*, *balancier*, *pendulisant*, etc. In *Holland* it is known as *wichelroede*, *wichelstok*, *toverstaf*, *orakelroede*, *geluksroede*, *wensroede*, *toverroede* and *vondelhout*, the diviner being called *roedeloper*, *waterloper*, *rhabdomant*, etc. In *Denmark* the divining rod is known as *Spästikke*, in *Norway* as *önskekvist*, in *Sweden* as *slagruta*.

The divining rod can be held in different ways, as indicated in figs 84-88; the most common methods are represented in figs 84 and 86.

In fig. 88 the *straight-rod type* is shown, which was rather common in olden times. It consisted of one or two pieces but is now obsolete.

Fig. 90 (III) shows a heavy and light type of *angle-rod*. Maby (Bibl. No. 1111, p. 22) described this type of rod as follows: "It consists essentially of a piece of rigid material, such as a thin metal rod, bent to a right angle of about a third or a quarter of its length from one end; the shorter section being held vertically in one hand in a loose grip, while the other parts projects forwards horizontally". The free

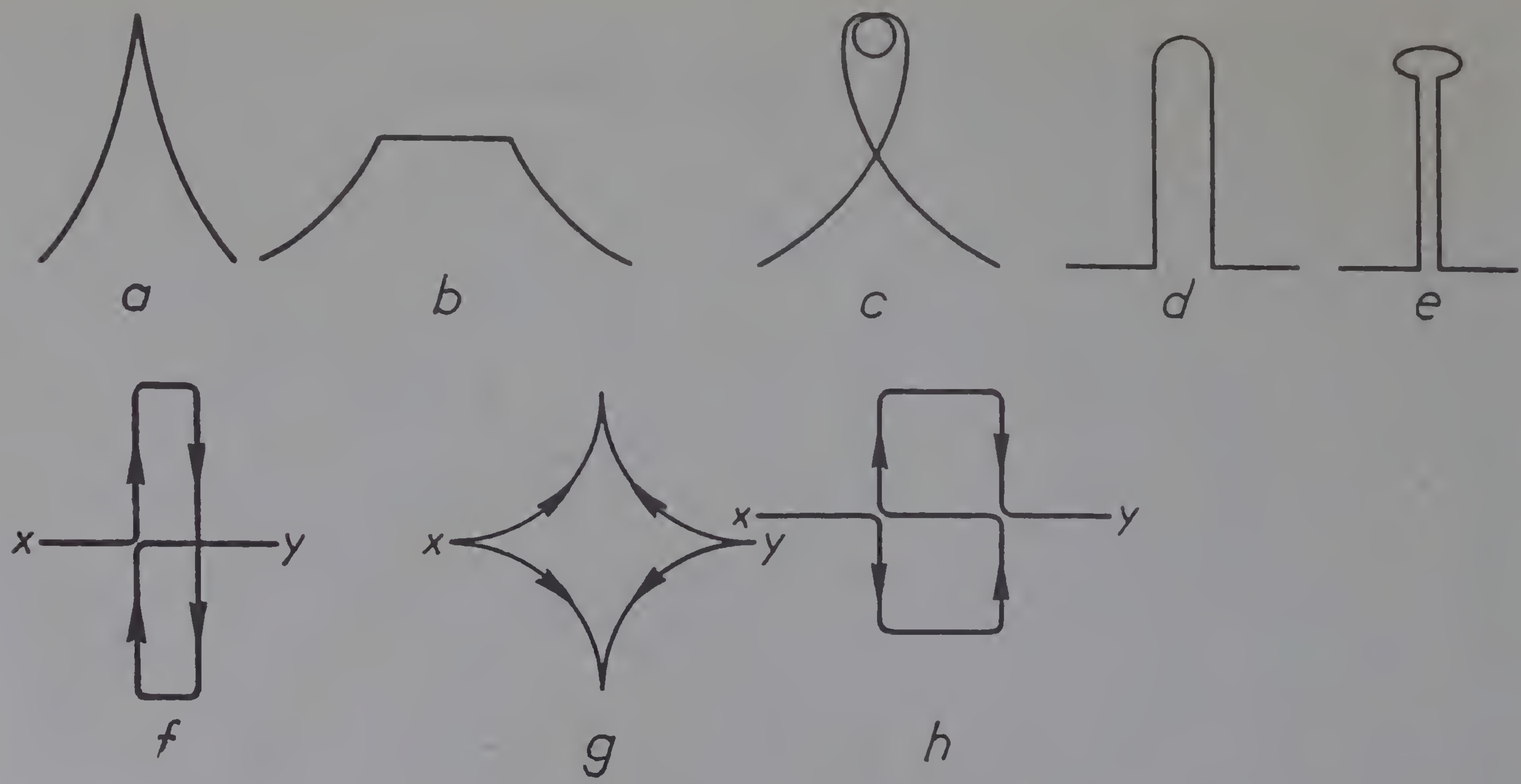

Fig. 89: (Bibl. No. 1370, p. 408) Different types of metal rods used by WÜST and WIMMER during their experiments.

III IV

Fig. 90: (Bibl. No. 1111) Method of holding a swivelling angle rod (III) and a reaction-meter or tonometer (IV).

horizontal part of the rod tends to swing inwards towards the chest on encountering a dowsing zone, the action being facilitated by using a special handgrip within which the vertical part of the indicator can swivel freely (if lubricated). The lighter form seems to be the most sensitive. It is generally held at waist height with forearm horizontal and elbow at the side.

Certain dowsers seem to be sufficiently sensitive in that they can *trace dowsing zones by merely using sensations in their hands*. The experiments by the author (see p. 325, point 5) appear to confirm this statement. Apart from changes in muscular tension these extremely sensitive dowsers have feelings of "cold shivers", "pins and needles", nausea, headache, staggers, etc.

Of particular interest is the observation of MABY that if a dowser is blindfolded and asked to stretch out both arms and hands straight before him at shoulder height and then asked to walk forwards slowly into a strong dowsing zone, the hands draw a little nearer together; passing in the opposite direction the reverse happens. In this experiment the hands should not be held palms uppermost.

MABY developed the *separometer* for more accurate quantitative measurements. It consists of two tubes, resembling a bicycle pump, one graduated in inches and tenths, sliding very freely within the other. The two handles attached to both tubes are held with the thumbs upwards, palms of the hands facing one another, forearms more or less horizontal. A special type of separometer was developed by MABY, known as *tonometer* (see fig. 90 IV). In this case the dowser's reaction is counteracted by a spring, the reading being magnified by a dial and pointer arrangement.

This short review of the main types of divining rods and the manner in which they are held is sufficient to allow the following discussions on dowsing to be understood. Those interested in further details are referred to the publications mentioned in the bibliography, marked with a star, and in particular to the publications of MABY.

3. Summary of observations of dowsers

It is evident that considering the enormous number of publications on dowsing, it is utterly impossible to give a complete summary of all reported dowsing phenomena. We therefore had to make a choice and decided to report only those phenomena which the author has been able to check personally and also phenomena whose reality, although not yet checked, call for intensive research as soon as the occasion arises.

The dowsing phenomena can be divided into three groups:
A. observations above non-living objects; B. observations above living organisms (plants, animals and man); C. medical observations.

Each group is briefly discussed. Further details can be found in section (5): "New synthesis of the causes of divining rod phenomena" on p. 309.

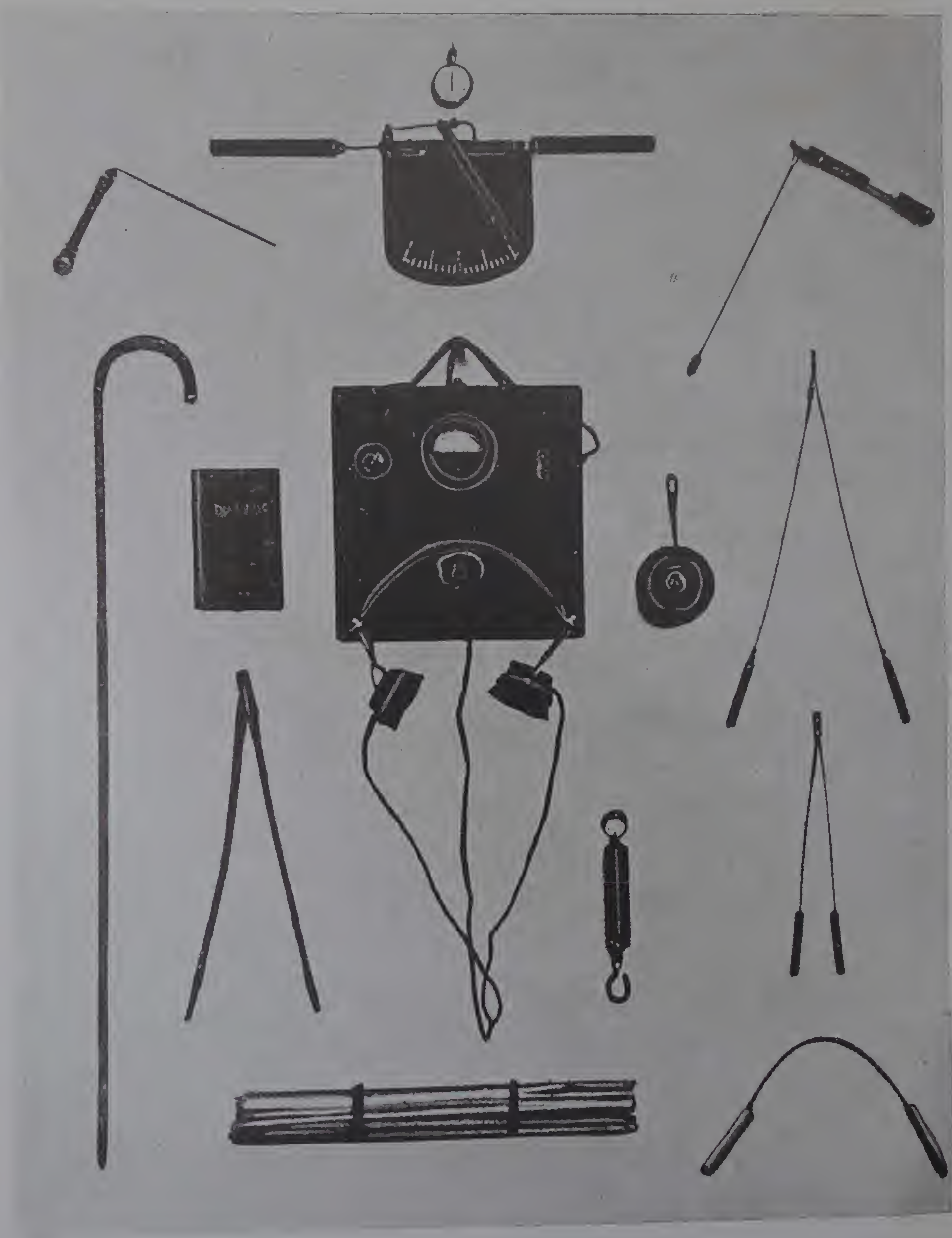

Fig. 91: (Bibl. No. 1111) Collection of dowsing implements after MABY: portable ionization counter (centre); stopwatch; extension dynamometer; reaction meter (top centre); depthing and testing rod (mumetal walking stick); two swivelling angle rods; steel-, whalebone- and wooden forked rods and a bowed steel rod.

A. Observations above non-living objects

Two kinds of disturbing dowsing zones can be distinguished: local and regional.

3. A. 1. Local disturbances

Dowsers have observed that when passing certain objects or crossing a line or zone in houses or in the open air, the forked divining rod tends to rotate downwards or upwards, or it turns upwards on one side only, in the case of loop-shaped wires (see fig. 87). In the open air the diameter of the local disturbances (at least in one direction) is between 50 cm and 50 m (seldom up to 100 m). Different causes are known to create such local disturbances in the open air: water wells; locally circulating groundwater (mostly indicated by a zone with a small diameter in one direction and very long in a direction perpendicular to it); water-pipes, oil pipes, etc.; bundles of electric wires; roots of big trees; subterranean caves; geological faults; ore deposits; local changes in mineral composition of rocks, their texture and structure (creating variations in porosity, permeability, moisture content, etc.); electric power lines; buried foundations; excavated archeological sites refilled with other soil; etc. Sudden changes in vegetation might also create slight dowsing reactions.

In the case of underground sources of disturbance (of equal intensity) the rule is prevalent that the deeper the source the weaker the surface reaction and the greater the diameter of the zone of disturbance.

Weak local disturbances in houses are generally caused by water pipes, central heating pipes, reinforced concrete beams, stoves, radiators, furniture, neighbourhood of living bodies, etc. If a dowser approaches within 50 cm of the stone wall of a house (either in open air or in the house) he usually observes a slight turning of the rod, particularly if loop-shaped conducting wires are used. If the walls are covered with thick paper the influence is usually missing. Very strong zones of local disturbance are found in houses, often occurring at different floors above each other and continuing in the open air over long distances.

3. A. 2. Regional disturbances

In certain areas the divining rod starts turning on entering this area and the rod remains turned for hundreds of metres or even for a few KM., but the rate of turning generally fluctuates. Such disturbances were observed:

a. *on land:*

1. above folded strata on the surface of the earth, but also above sub-surface folds covered by a thick layer of horizontal sediments; the axis found by divining seems usually to coincide better with the sub-surface than with the surface axis;

2. above large igneous massifs (particularly basic rocks, i.e., rocks poor in silica and rich in iron-magnesium minerals) or volcanic lava flows.

b. *on sea:*

1. above fault blocks on the bottom of the sea;
2. above submarine basalt flows.

These observations were made by the author in 1944 in the Red Sea Area and Gulf of Aden. In the Indian Ocean, far from the coast, no dowsing reactions were observed until the Australian coast was reached.

Each of these reactions is influenced by a great number of factors, such as conductivity of the skin, etc., which we discuss in section (5), p. 361, in our own experiments on dowsing.

The direction of turning with most dowsers varies with the direction of movement and is constant for a certain direction; the rate of turning, however, usually varies with the hour of the day and time of the year.

B. Obervations above living organisms

3. B. 1. Observations above plants

We have already mentioned the disturbing influence of long roots of big trees on dowsing. In general it can be said that most dowsers, if they approach trees (similar to approaching a stone wall) observe a slight turning of the rod.

The neighbourhood of small plants cannot usually be felt unless a very fine metal wire is connected to the conducting loop-shaped rod (see fig. 86). If the dowser stands quietly and the additional wire connects the rod to leaves or other parts of a plant, the rod starts turning after a few seconds (varying for the type of plant and the part which is touched). The direction of turning is different for different parts of a plant and generally is different for the upper and lower part, in other words a pronounced polarity is observed.

3. B. 2. Observations above animals

Large animals create similar disturbances in a rod as man; these phenomena, therefore should be dealt with later on. Different observations have been reported by dowsers on the behaviour of animals in dowsing zones. Although their statements are not conclusive and the observations are usually based only on a few cases, it seems worthwhile to test them seriously.

a. According to Jenny (Bibl. No. 1012, 1013) *mice* placed in long cages which were crossed by a dowsing zone always seem to concentrate in the part outside the zone.

b. *Horses* and *cattle* do not seem to graze in those parts of a meadow which are crossed by strong dowsing zones. However, if the

grass is cut in these places and given to them in the stables they enjoy eating it.

c. *Chickens* seem to sleep only in places free of dowsing zones if a poultry house is crossed by such zones.

d. It has been reported that *bees* produce more honey if the beehive is placed in a strong dowsing zone.

It is evident that these observations must be tested very carefully for long periods before a positive or negative statement can be made. However, if these observations prove to be correct, a great number of applications in biological and veterinary sciences could be thought of. This makes a scientific research even more attractive.

3. B. 3. Observations above man

If a man (or woman) lies on a settee and a dowser is moves with the rod along that person above the body, the rod starts turning or rotating (with the forked type), the direction of turning being different at the lower and upper part of the body and neutral near the middle. When a loop-shaped conductor is used (see fig. 86) the following details can be observed: if the (male) dowser moves with his chest parallel to the axis of the body of a person lying on a settee, his arms with the rod perpendicular to the axis above the body, we notice that moving from feet to head (right hand nearest to the head), with a male person on the settee, near the feet first the left hand comes up, near the middle of the body the hands are even and near the head the right side of the rod comes up (see fig. 87). If this experiment is repeated on the other side of the settee, with the left-hand side nearest to the head, the right hand side comes up near the feet, the left-hand side near the head. In the case of a woman the phenomena are reversed. Young boys sometimes create a female reaction. It seems that certain dowsers obtain female reactions above males and the male reactions above females. This might be due to a different polarity of their hands (see later)

After the trial person has risen from the bed or settee the dowser can still observe the same reaction above that bed or settee for many hours or even days afterwards. This observation we have called the "*shadow phenomenon*"; it is explained on p. 364. If the settee or bed is earthed sufficiently (in case of a mattress on a bed the earth wire has to be brought in contact with several places of the mattress) this double-reaction is missing.

A similar shadow phenomenon can be observed above chairs. In the case of a male the left-hand side comes up; if a female had been sitting on this chair the right-hand side comes up (see fig. 87).

C. Medical observations

3. C. 1. Influence of dowsing zones on general health

A great number of dowsers have reported the unfavourable influence

of strong dowsing-zones on persons living a considerable part of their life in these zones, particularly if two or more zones cross each other at the place where those persons sleep or work. In addition to the important studies on dowsing such as the publications of KLINCKOWSTROEM (Bibl. No. 1039) and MABY (Bibl. No. 1111) the following authors have expressed their opinion on this subject and have reported a number of cases which according to their point of view should "prove" the reality of the statement: BEITZKE (Bibl. No. 740), BIRKELBACH (Bibl. No. 762), BONGERS (Bibl. No. 771), VAN DAM (Bibl. No. 828), EBERT (Bibl. No. 865), FISCHER (Bibl. No. 895), GODDARD (Bibl. No. 946), DE GROOT (Bibl. No. 962), HEISLER (Bibl. No. 980) HOLTZ (Bibl. No. 996), JEMMA (Bibl. No. 1011), JENNY (Bibl. No. 1013), KIPPOLD (Bibl. No. 1022), KLEIBEUKER (Bibl. No. 1028), LAKHOVSKY (Bibl. No. 1063), MIEREMET (Bibl. No. 1143), VON POHL (Bibl. No. 1190, 1191), RAMBEAU (Bibl. No. 1203), SIMONIS (Bibl. No. 1279), WINZER (Bibl. No. 1365).

Although none of these authors has been able to collect sufficient trustworthy material which could stand a critical statistical test, their observations are of sufficient interest to recommend an intensive scientific research over a long period; the more so, as the phenomena discussed in chapters I and II suggest that theoretically such an influence seems to be quite possible, if one could prove the reality of the dowsing zones and explain the cause of the dowsing reaction; in other words if we would know the pattern of forces which seem to dominate the dowsing phenomena. Therefore we shall discuss this medical influence more extensively only after these two problems have been solved.

It is evident that the solution of this medical problem, even if only part of the statements of dowsers proves to be correct, is of greatest importance to medical science and the study of social hygiene in general, as one might have to take special precautions in building houses, in particular hospitals, in placing our beds, etc. If no theoretical evidence could support the assumption, one might consider such a research a waste of money but with our present knowledge of the influence of external electro-magnetic fields on living organisms, such a research is almost bound to repay itself.

Several of the authors mentioned consider the influence on cancer development to be of the most dangerous effects of dowsing zones. VON POHL, for example, made a statistical study on "cancer houses" in the town of Vilsiburg (Germany) and concluded that all cases of cancer occur in those houses where people had slept for many years in strong dowsing zones, particularly crossing zones. One never knows, of course, whether VON POHL knew all these houses before the experiments started. The same applies to the experiments of Dr VAN DAM and MIEREMET in Friesland (Holland), where (according to these authors) similar striking examples of coincidence between dowsing zones and cancer houses were found. The honest dowser is inclined to be offended if the trustworthiness of such results are doubted. It must not be forgot-

ten, however, that suggestion can play an enormous role in these extremely subtle observations and that one cannot be critical enough as long as not an instrument can be used in place of the human body.

According to JENNY (Bibl. No. 1012, 1013) mice obtained tar-cancer much more quickly if they were placed in strong dowsing zones. Prof. LAKHOVSKY (Bibl. No. 1063) made a statistical study in Paris and came to the conclusion that houses above clay and marl soil (being good conductors) had most cases of cancer, whereas few carcinoma cases were reported from houses on very sandy soil. On p. 225 we have given a few resistivity data of rocks: clay $5 \cdot 10^2$-10^5 ohm/cm, marls $0.5 \cdot 10^2$-$7 \cdot 10^3$, shales $8 \cdot 10^2$-10^6, sandstone 10^3-10^7, sand 10^1-10^5, limestone $6 \cdot 10^3$-$5 \cdot 10^7$, loam 10^3-$4.5 \cdot 10^4$.

We have seen that the moisture content of the rocks, which depends greatly on their porosity, permeability and cleavage, mainly dominates the ultimate conductivity in the soil. Although clays, because of their great absorption capacity for water, generally have a resistance very small compared with sandstones, i.e., a conductivity very large, many exceptions to this rule can be found which are due to different geological circumstances. A simple relation such as LAKHOVSKY indicated is not therefore very plausible. Nevertheless, some kind of relation might exist. Only a close cooperation between a medical doctor and a geologist could reveal the existence of a certain relationship between cancer and soil. As the contrast between highly conductive soil and neighbouring areas with small conductivity seems to be able to create strong dowsing zones (see p. 322, importance of gradients) it might be possible to find a relationship between cancer houses and dowsing zones which is not purely imaginative.

Dowsers also reported other psychic and physiological disturbances as a result of dowsing zones: insomnia, restless sleep, nervousness, thrombosis, rheumatic diseases, asthma, phlebitis, continuous headaches, nausea, tuberculosis, etc. The fact that some people sleeping in the same zone do not observe these phenomena does not disprove these observations. We have mentioned previously that not everybody is sensitive to atmospheric changes. It is well known to every rheumatologist that because of certain unknown external circumstances patients might suddenly improve or conditions might deteriorate. The change of a room or of a house sometimes is sufficient. Changes in humidity, temperature or light do not seem to be the cause in these cases.

We have seen also that the influence of weak magnetic fields is only normally observable after years, whereas extremely sensitive people might observe the influence in considerably shorter time (see also p. 283, influence of HERTZIAN waves). The influence of a dowsing zone, if existing, should probably not be sought in a specific medical effect but in an undermining of the general body resistance against infectious diseases, etc. We have seen that both electric, electro-magnetic and purely magnetic fields can influence the body resistance either after short

treatment in case of strong fields or after many years if the disturbing fields are very weak. The influence does not need to be harmful; certain experiments even suggest a favourable effect (see e.g., experiments on p. 272). If dowsing zones are somehow related to any of these external fields, the relationship between dowsing zone and human health is by no means imaginary. On the contrary, if dowsing is a reality and due to external electro-magnetic fields, a scientific research of the influence of dowsing zones should be started at once. It will take many years of concentrated work in which different scientists, such as meteorologists, geologists, neurologists, physiologists, rheumatologists, etc., must cooperate very closely.

From the previous discussions it is evident that the first problem to be solved is to seek positive evidence for the reality of dowsing phenomena and we must be able to prove that they are due to variations in the external fields surrounding the dowser. This will be ihe main object therefore of section 5 of this part on rhabdomancy.

3. C. 2. Other medical observations of diviners

a. *Experiments of* DR W. E. BOYD: We discussed on p. 111 the experiments of Dr BOYD with the emanometer; this is another example of divining that might be related to the phenomena observed by dowsers above human beings.

b. *Experiments of* Dr ALBERT ABRAMS (see Bibl. No. 689): ABRAMS, in his laboratory in San Fransisco in the early nineteen twenties, showed that if a healthy person (the "subject") is connected through a special circuit with a person suffering from some disease, the abdominal muscles of the former undergo a change of tone, demonstrable by percussion, when the circuit is tuned to a particular frequency different for each disease. Having listed the frequencies of numerous diseases and found them constant, ABRAMS used his circuit for diagnosis, trying a succession of frequencies until the reaction occurred. This happened only when the "subject" stood facing west. This method is closely related to that of BOYD and was, as could be expected, ignored by the majority of medical scientists as it "sounded so peculiar and abnormal". As usual the facts were rejected as they did not seem to fit into the frame of mind of the average 20th century scientist and could not be explained by current theories. We have already mentioned a great number of peculiar dowsing effects and we shall demonstrate that each of them is a reality and can be explained by current theories, if we are only willing to use the right experiments and instruments. Although we have no experience with the methods of Dr BOYD and ABRAMS, their publications indicate that a number of qualified scientists are working on these problems and the final solution might be closely related to the problems dealt with in the following pages.

c. *Experiments of dowsers above human urine:* Dowsers find a pro-

nounced turning of the rod, above human urine in a basin; this is different in the case of male or female urine. On p. 118 we indicated the difference in the urine of the sexes. It is interesting that with a loop-shaped rod (see fig. 86) above female urine the right-hand side comes up (see fig. 87), whereas in case of male urine it is the left-hand side.

These few examples of medical observations of dowsers are sufficiently complicated if an explanation is sought, so it seems unnecessary to increase the number of problems by giving more examples.

4. Summary of theories explaining water divining

The different theories which have tried to explain the dowsing phenomena can be divided into two groups. One believes in unknown external forces which directly turn the divining rod. The number of present-day adherers of this theory is very small although the author at present knows some, even amongst capable physicists, who are convinced of the reality of dowsing and who believe in such a divine unknown force.

The majority of modern dowsers, however, are convinced that the turning of the rod is caused by a muscular action of the forearms. The first dowsers who expressed this opinion were KIRCHER in 1645 (Bibl. No. 1023) and the Jesuit Father SCHOTT in 1659 (Bibl. No. 1260). The theories that accept unconscious muscular action as the cause of the turning of the rod can again be divided into two groups. One believes in purely psychic processes, which are reflected in physiological processes stimulating the muscles of the arms (theory of BARRETT, Bibl. No. 722); the other group believes in ordinary physical external forces which are directly or indirectly registered by our muscles. The latter group of theories, which is rather generally accepted by the majority of physically trained dowsers, can be divided again into different theories of which the most important are the following:

1. *Attraction theory:* this was generally accepted in the 17th century as a result of the discovery of the phenomena of magnetism and gravity. The rotation of the rod was explained as the principle of "sympathy" or "attraction or repulsion."

2. *Electric theories:* the first theory was advanced about 1780 by PIERRE THOUVENEL (Bibl. No. 1301) and found special support in C. LATIMER (Bibl. No. 1072) in the U.S.A. about 1870. Different theories have been put forward since, of which the most modern variation was suggested by F. LEIRI in about 1934 (Bibl. No. 1083), who explains the effect of so-called "water veins" (an expression used in all dowsing literature and which sounds most ridiculous to a geologist) by "current potentials" in the soil. This would be reflected in the skin potentials and create a stimulus on the muscular nerves.

3. *Electro-magnetic theories:*
   a. *earth-ray theories:* the majority of modern dowsers explain the dowsing phenomena as being the result of a radiation from the earth, either directly as an unknown radiation or indirectly as reflected cosmic or other rays. Scientific evidence for this theory has not been found.
   b. *theory* of HERTZIAN *waves:* this theory, particularly developed by MAGER (Bibl. No. 1113-1124) and MABY and FRANKLIN (Bibl. No. 1111), assumes the action of HERTZIAN waves on our muscular nerves, the waves being created by subterranean discontinuities. MABY'S theory is discussed more extensively in the following section.

We shall demonstrate that none of these theories can explain the divining phenomena. They are all, one more than the other, rather superficial as far as the physiological part is concerned, which is the most difficult part in the explanation of dowsing phenomena. Still, unless both the external geophysical and the internal physiological processes can be explained logically no theory can be considered conclusive.

A great difficulty in the explanation of divining phenomena is also caused by two other factors:

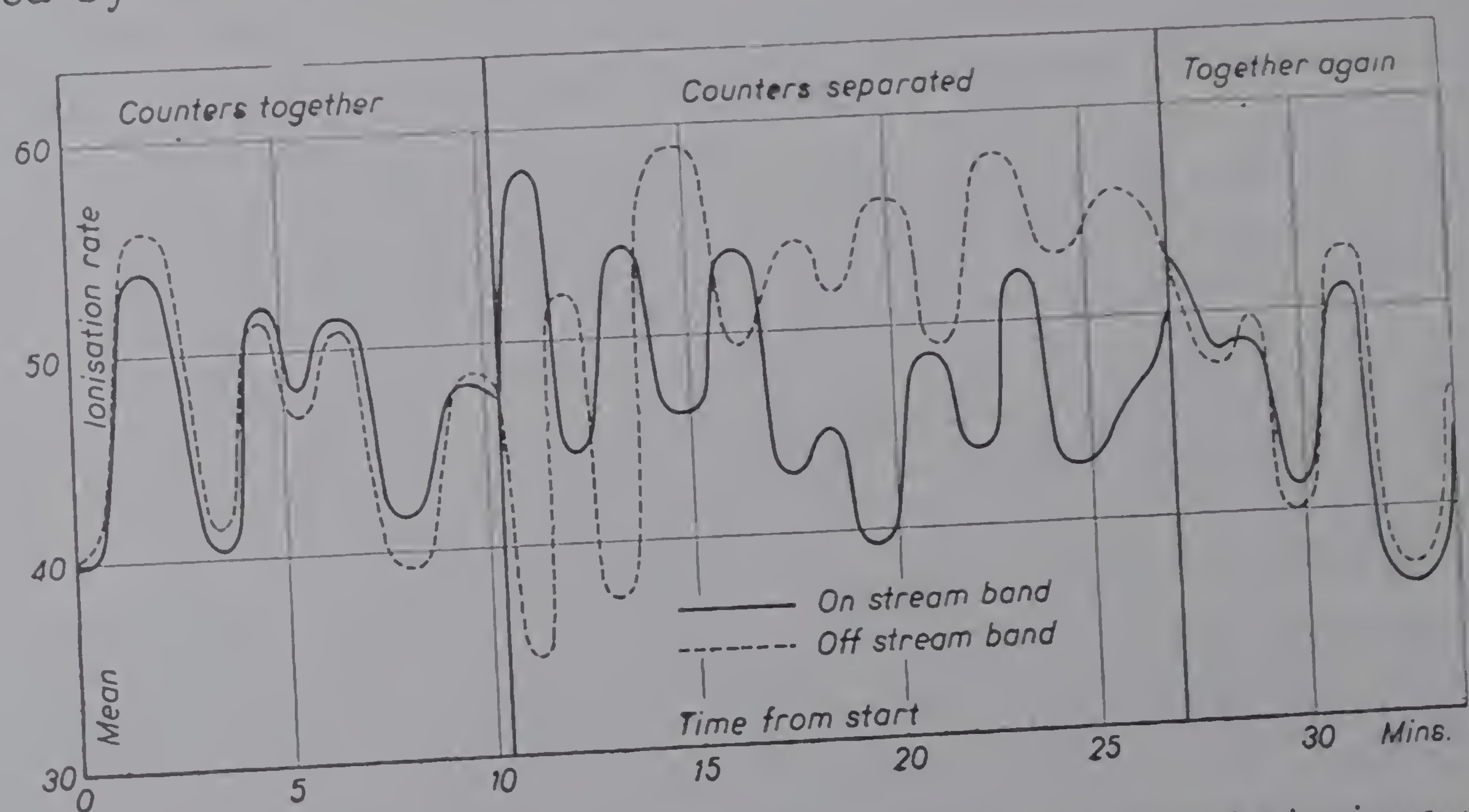

Fig. 92: (Bibl. No. 1111, p. 118) Behaviour of two similar neon-tube ionization counters when one is on a dowsing R-band and the other on an adjacent N-band of the field of an underground stream. Note close parallelism of the two records (slightly smoothed) when the counters are together (two end sections of graph), changing to a more or less opposite behaviour when about 6 ft apart on the oppositely polarized bands.

1. The more we study the problem of dowsing, the more we are forced to accept several external causes of muscular stimulation. We cannot speak of one physical cause of divining phenomena.
2. As a direct result of the previous statement and because all dowsers do not react in the same way on these different external forces, the

final result, which is reflected as a certain observed dowsing reaction, is bound to be different for a number of dowsers. Consequently, there is hardly any dowsing phenomenon which occurs with all dowsers in exactly the same way and it requires a considerable amount of experimental work before more general rules can be laid down.

In the following pages we try to build up a new theory which might explain all known dowsing phenomena, both physically and physiologically.

5. New synthesis of the causes of divining rod phenomena

This last section of part I on rhabdomancy is divided into 6 parts:

In section A the experiments of the author are discussed which were started with the main purpose of establishing once and for all whether the dowsing phenomena really exist or whether they are only the result of suggestion (either auto-suggestion or suggestion by people in the neighbourhood of the dowser).

In section B the most important observations of DE VITA, JEMMA, MABY and WÜST are discussed.

In section C we endeavour to give a synthesis of the physical and physiological processes during dowsing phenomena above living and non-living objects, and a tentative explanation of the "shadow" phenomenon.

In section D the causes of error during dowsing experiments are summarized.

In section E a summary is given of the precautions to be taken during dowsing.

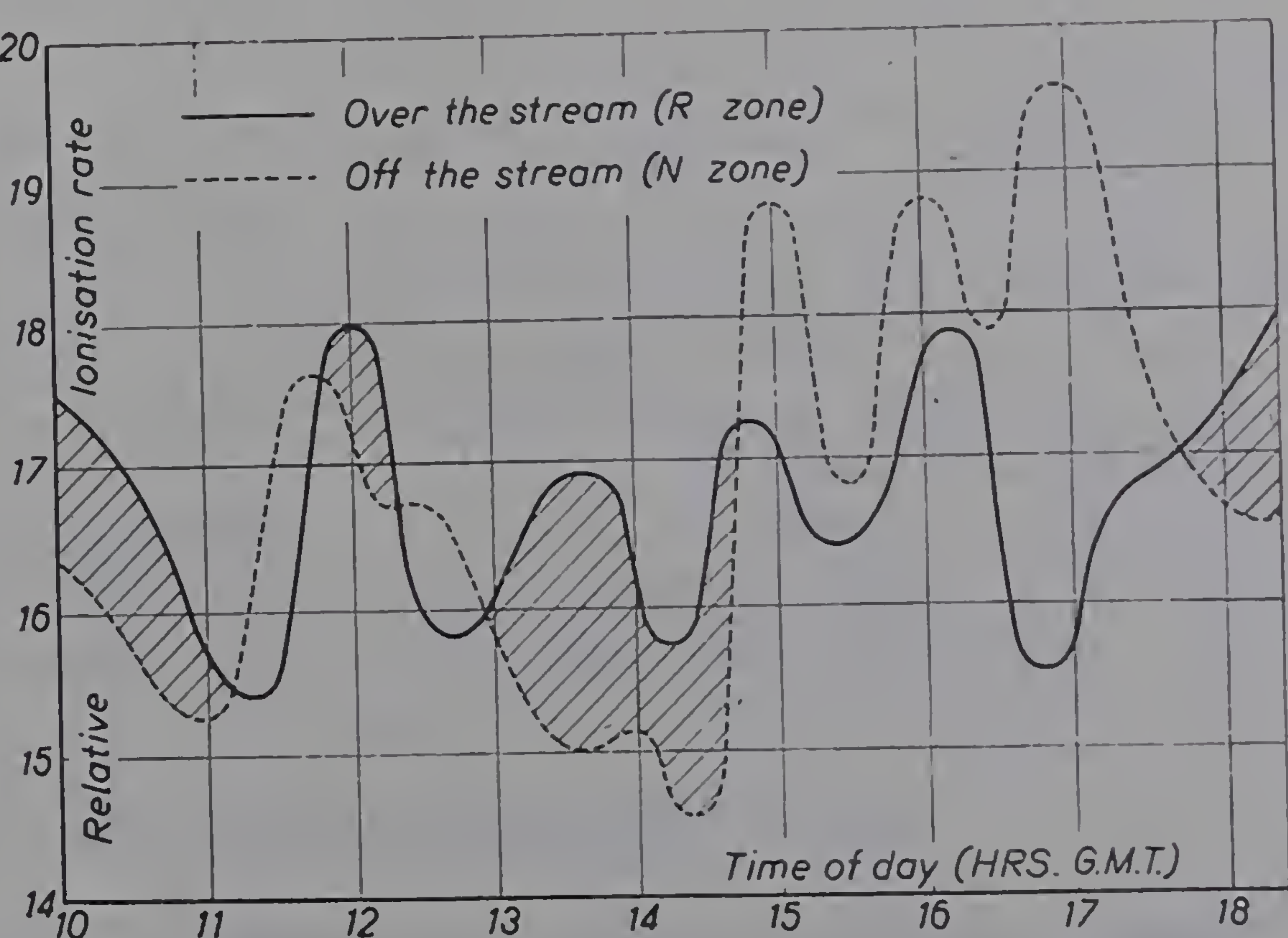

Fig. 93: (Bibl. No. 1111, p. 116) Variations of mean ionization rate over and just to one side of an underground stream, employing a neon-tube counter. Periodic fluctuations at both stations are sometimes roughly parallel, at others opposite, with values alternately higher at one or other station, the curves being smoothed to eliminate short period changes occurring more or less frequently.

In section F the possible influence of dowsing zones on the health of man is discussed and the different medical phenomena, mentioned in previous chapters are summarized.

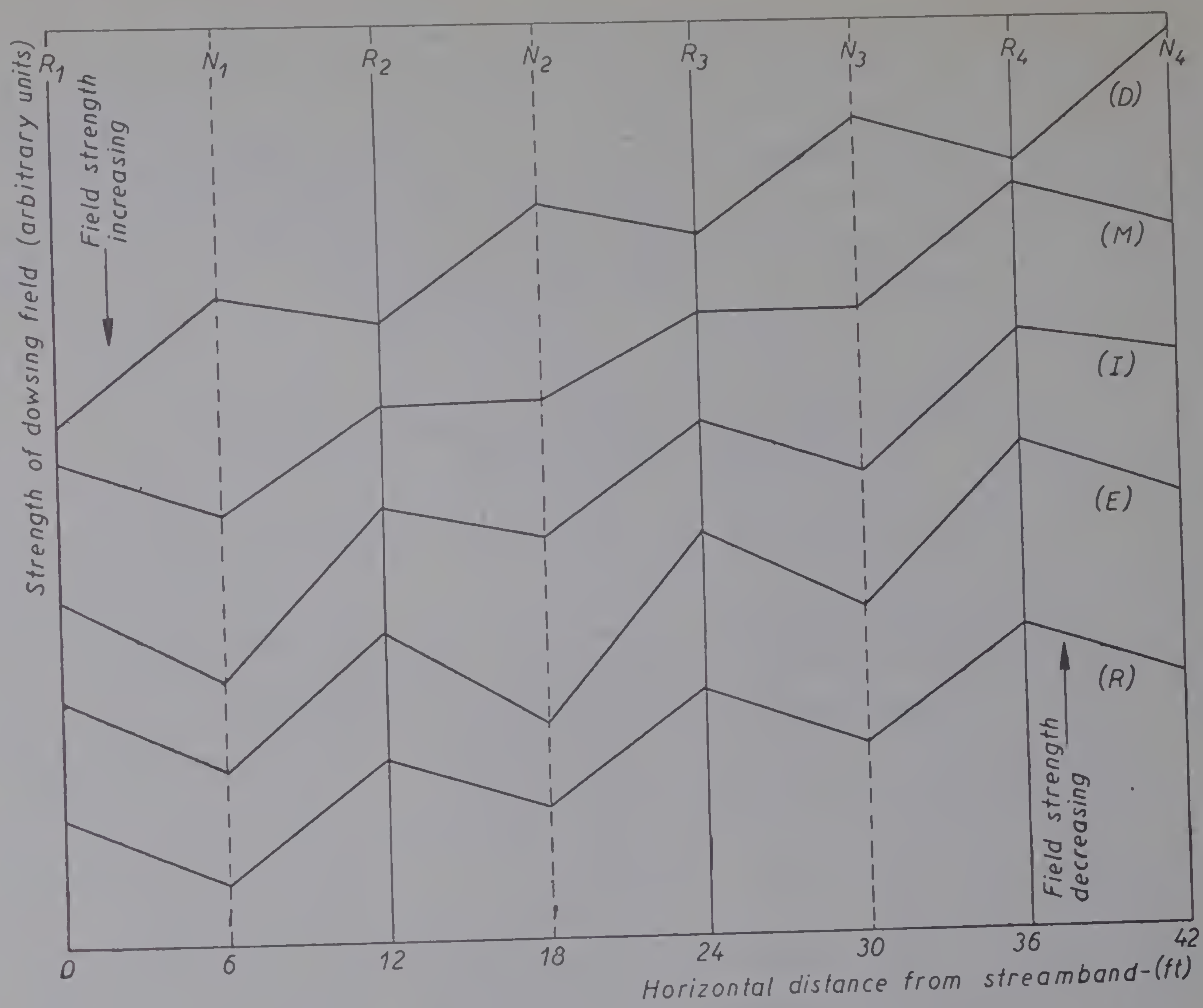

Fig. 94: (Bibl. No. 1111, p. 138) Undulatory variations of field strength relative to the R- and N- bands of dowsing reaction associated with an underground stream. Readings taken at mid-N and mid-R positions, the results of many successive traversals averaged.

D. Dowser's muscular strength.
M. H Magnetic intensity.
I. Relative ionization rate.
E. Ground electric potential.
R. Radio signal strength.
(All detectors similarly orientated)

A. Experiments by S. W. Tromp (1947)

From September 1946 to June 1947, a number of experiments were carried out by the author, first in the Physical and the Physiological Laboratories in Leiden (Holland) and later in the laboratory of Technical Physics in Delft (Holland).

The experiments consisted of three main groups:

1. experiments with artificial magnetic fields (assisted by Van der Starre, Chief Technical Assistant in the Physical Laboratory);
2. experiments with a string galvanometer of Einthoven (carried out with the assistance of M. J. De Groot, technical inventor of the string galvanometer of Einthoven);
3. electro-static experiments (carried out with the assistance of the Physical Engineer, H. de Zeeuw).

The main purpose of these experiments was to find a method that enables us to prove or disprove convincingly the reality of dowsing reactions.

The first group of experiments was carried out because the author had noticed during geophysical work that dowsing reactions seem to coincide with magnetometer maps. At that time he was not yet aware that many other physical phenomena, besides the disturbances in the magnetic field of the earth, can be responsible for dowsing phenomena.

The second method was chosen in order to study the fluctuations of skin potentials of dowsers with a continuously self-registering millivolt-meter.

The third group of experiments was carried out in order to study the influence of electro-static induction on dowsers.

The preliminary results of these experiments were published in Bibl. No. 1447 and 1448 and in a stencilled appendix.

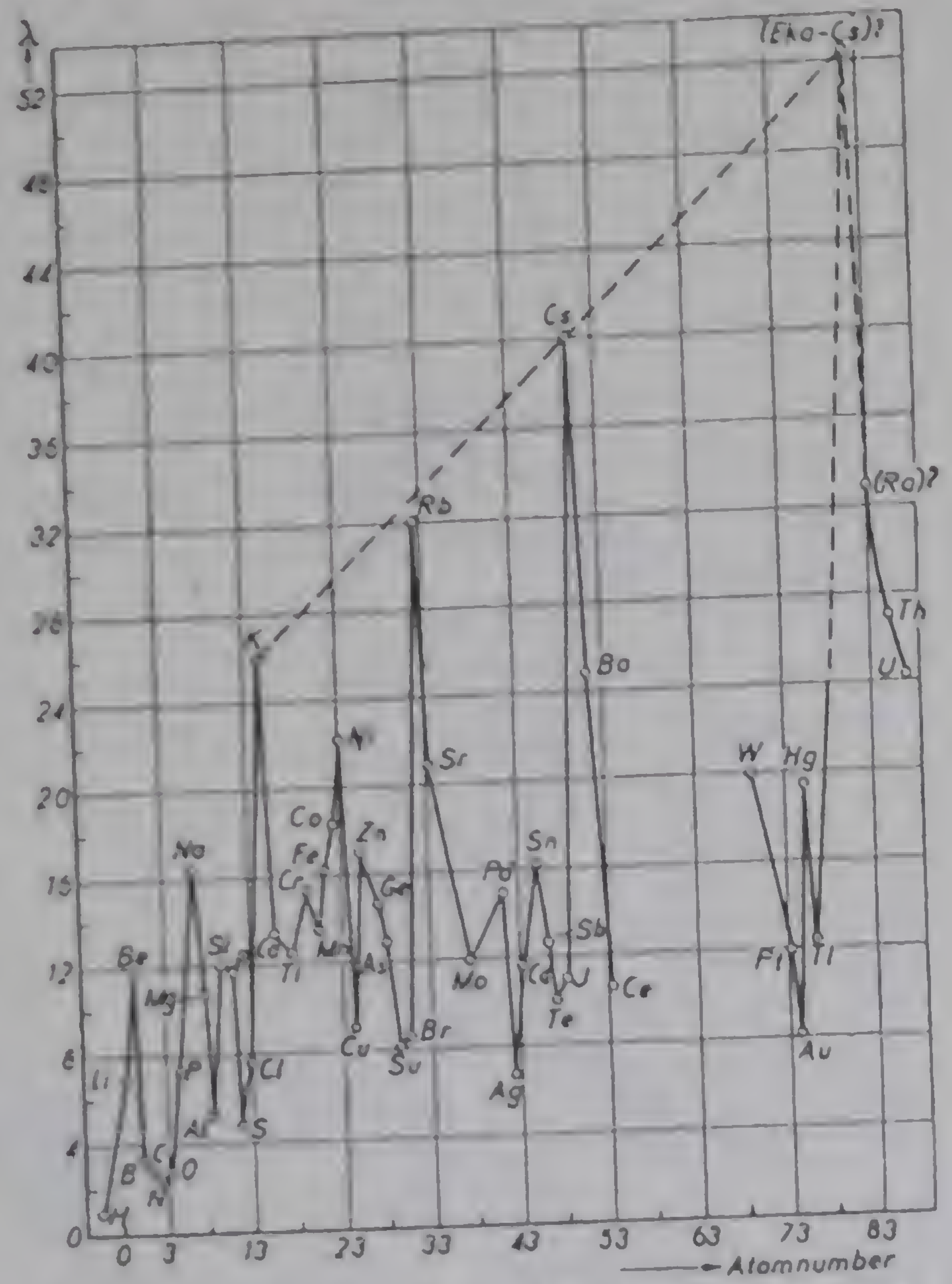

Fig. 95: (Bibl. No. 1370, p. 442) Relationship between rate of turning of a divining rod above different elements and their atomic number.

The author believes that with these experiments it is possible to prove the reality of dowsing phenomena.

Before we discuss the experiments in detail, a short summary is given of the main results that support the statement *that the reality of dowsing phenomena could be proved with at least four different independent methods*:

5. A. 1. Artificial magnetic fields

Artificial constant magnetic fields developed by a tangent galvanometer with a ring of 1 metre diameter (see fig. 96) and one single electric coil, creating by an electric current of 10 A a field strength of 0.125 Gauss in the centre and of 0.001 Gauss at a distance of 230 cm from the ring, could be registered by a blindfolded dowser holding a loop-shaped rod (see fig. 86), as long as sudden variations in the field strength of that magnetic field were created. These variations were obtained either by movement of the dowser from a point outside the field into the field or by changing suddenly the angle of the ring of the tangent galvanometer (the dowser standing quietly in front of the ring), by switching the current on and off or by changing the direction of the current. In all these experiments neither the dowser nor the person who registered the dowser's reactions knew whether the current was on or off; the

contacts were completely noiseless and the handling of the switch by a third person could not be seen, although all three persons were in the same room. As a special precaution thick cotton-wool was placed in the ears of the dowser.

Fig. 96: Tangent galvanometer used for development of artificial magnetic fields. O = wooden ring with diameter of 1 m; d = electric wire passing through the ring.

It was found that several dowsers (not all of them) were able to register these changes in the magnetic field without knowing that these changes occurred. They were apparently not able to register the field strength as such, only changes therein, i.e., a difference between a field created by 5 or 10 A current could not be distinguished, only a sudden change from one field into another.

The sensitivity to a field is bound to certain limits. Usually, if the electric current in the tangent galvanometer is less than 1 A the changes in field strength could no longer be registered, at least not by the trial persons at our disposal. The experiments showed that magnetic gradients of less than 0.001 Gauss/cm could be registered by sensitive dowsers.

The fact that a dowser, if he knows that a current is switched on, observes the same turning of the rod as when he is ignorant of the fact, seems sufficient proof that these phenomena are real and not merely suggestion.

The result was not completely unexpected if one considers the biomagnetic effects reported by others (see p. 264-282). Although the author has used constant magnetic fields (developed by a direct current) the experiments with a moving dowser indicate that this experiment can be compared with a non-moving dowser standing in slowly pulsating or very low-frequency alternating magnetic fields. We have seen that living matter is particularly sensitive to these kinds of fields, more than to constant magnetic fields. Although at present we cannot decide which of the phenomena mentioned on p. 79 are responsible for this magnetic reaction of dowsers, there is little doubt that magnetic induction currents in nerves might be one of the most important factors.

5. A. 2. Experiments with a string galvanometer of Einthoven

We described on p. 144 the mechanism of an instrument invented

by Prof. W. EINTHOVEN of Leiden Univeristy, and which was built by M. J. DE GROOT. On p. 154 we discussed the different methods of measuring the electro-cardiogram and in fig. 16 the main types of electro-cardiograms are represented. As our purpose has been to register continuously, with a millivolt-meter, the changes in skin potentials of a moving dowser, only lead I was used in our experiments (see p. 154). It was found (see later further details) that a loop-shaped rod (see fig. 86) does not turn in the hands of a dowser (at least not in the hands of the people used in our experiments) if the rod endings are placed in two insulated grips in which they can turn freely. By using a circuit as indicated in fig. 100 a current is made through the body and the rod; this enables us to register fluctuations of skin-potentials if the dowser moves through a dowsing zone without turning of the rod. In order to be certain that this new circuit does not change the electro-cardiogram, four basic experiments were made:
a. sitting quietly in a chair without a rod (see fig. 101); b. same experiment holding a rod in insulated grips (see fig. 102); c. standing quietly outside the zone of disturbance with a rod in insulated grips (see figs 103 and 105); d. walking with a rod in insulated grips outside a dowsing zone (no special photograph has been included here as the result of walking is indicated already in the left part of fig. 106).*

From all these experiments (which were repeated many times, with and without photographs) it was evident that the new circuit does not change the electro-cardiograms and that neither standing nor slow walking changes the level of the Q-peaks in the electro-cardiograms. This result is contrary to the general belief of heart specialists who are accustomed only to study diagrams of patients sitting quietly. However, this assumption has proved to be incorrect and is not based on actual observations. Not only does slow walking not influence the electro-cardiogram, but even fast driving in a car does not effect the string galvanometer as long as the dowser remains outside dowsing zones (see fig. 143).

After these observations were sufficiently established, the skin potentials and electro-cardiograms were studied with the dowser moving through a strong dowsing zone. In fig. 106 and following, which we discuss later on, electro-cardiograms are given which indicate considerable excursions of the general curve as soon as the dowser enters the dowsing zone and which becomes normal again after the dowser leaves the zone. In other words direct current potentials seem to appear besides the ordinary alternating current effect.

Similar phenomena were observed with people who are not sensitive to dowsing (as we shall explain later, the lack of a dowsing reaction is probably due to their high skin resistances), only the subsidence of the curve is less pronounced (see figs 115 and 118).

A careful discussion of these diagrams (altogether 130 photographs

* Fig. 101-150 are grouped together at the end of this publication (p. 407-431)

were taken, covering about 500 experiments) with different experts on electro-cardiograms and electro-myograms supported the author's opinion that the excursions of the curve are not due to ordinary *psycho-galvanic reflexes* (see p. 186). The main observations which seem to exclude this effect are the following:

a. The peculiar flat tops in figs 107, 109 a.o. are not characteristic of a psycho-galvanic reflex.
b. Sudden changes in the general level of the curves as described in figs 129-138 (for further details see later) and the changes observed in fig. 104 are difficult to explain by assuming an intention of the person to create such vertical jumps of the curve, moving sometimes upwards, sometimes downwards. Also, the type of curve is different from that of an ordinary psychogalvanic reflex. Finally, during the first experiments neither the dowser nor the observer knew what kind of curves would be obtained.

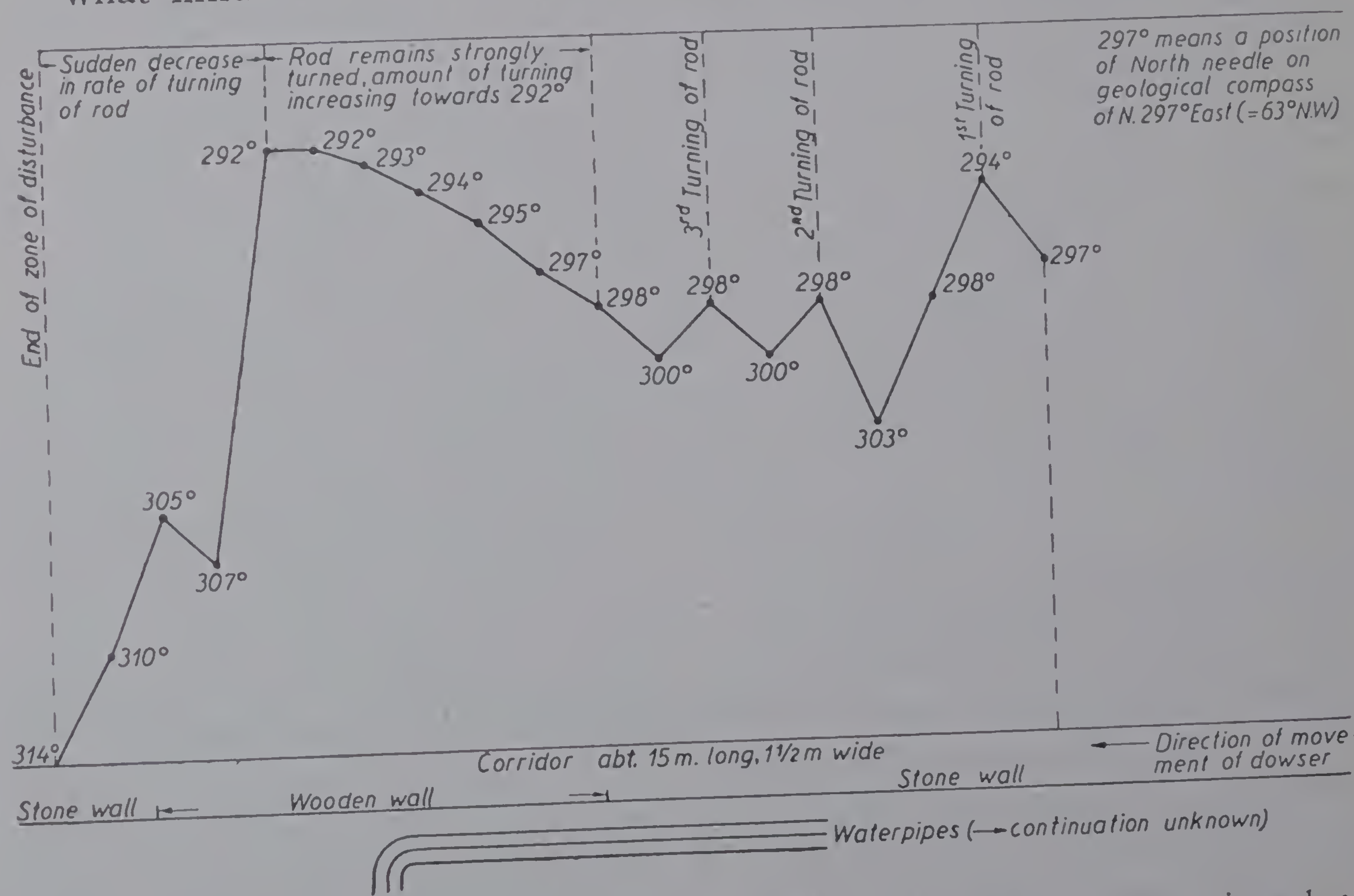

Fig. 97: Relationship between magnetic anomalies and dowser reactions in a long corridor in the physiological laboratory at Amsterdam (Holland).

c. The gradual but considerable rise of the curve, if e.g., the rod is kept above the head of a person (see fig. 137), is altogether a different type than in case of psycho-galvanic reflexes.
d. The first observations were made without knowing the result. After the latter was known the experiment was repeated above a bundle of wires in another room, where a similar reaction with the divining rod was obtained, although considerably weaker. No changes in the curves were observed although in this case a psycho-galvanic reflex could have been expected.

e. Physiologists pointed out the remarkable fact that during the previously discussed magnetic experiments, and during dowsing experiments in general, it always takes a few seconds between the moment the disturbing field is created and the first observed phenomena. If the diviner's reaction is not due to a direct electric impulse on the muscular nerves of the fore-arm, but to indirect stimulation via the central or sympathetic nervous systems it is logical that a certain latent period always occurs, which is also known in many encephalographic experiments.

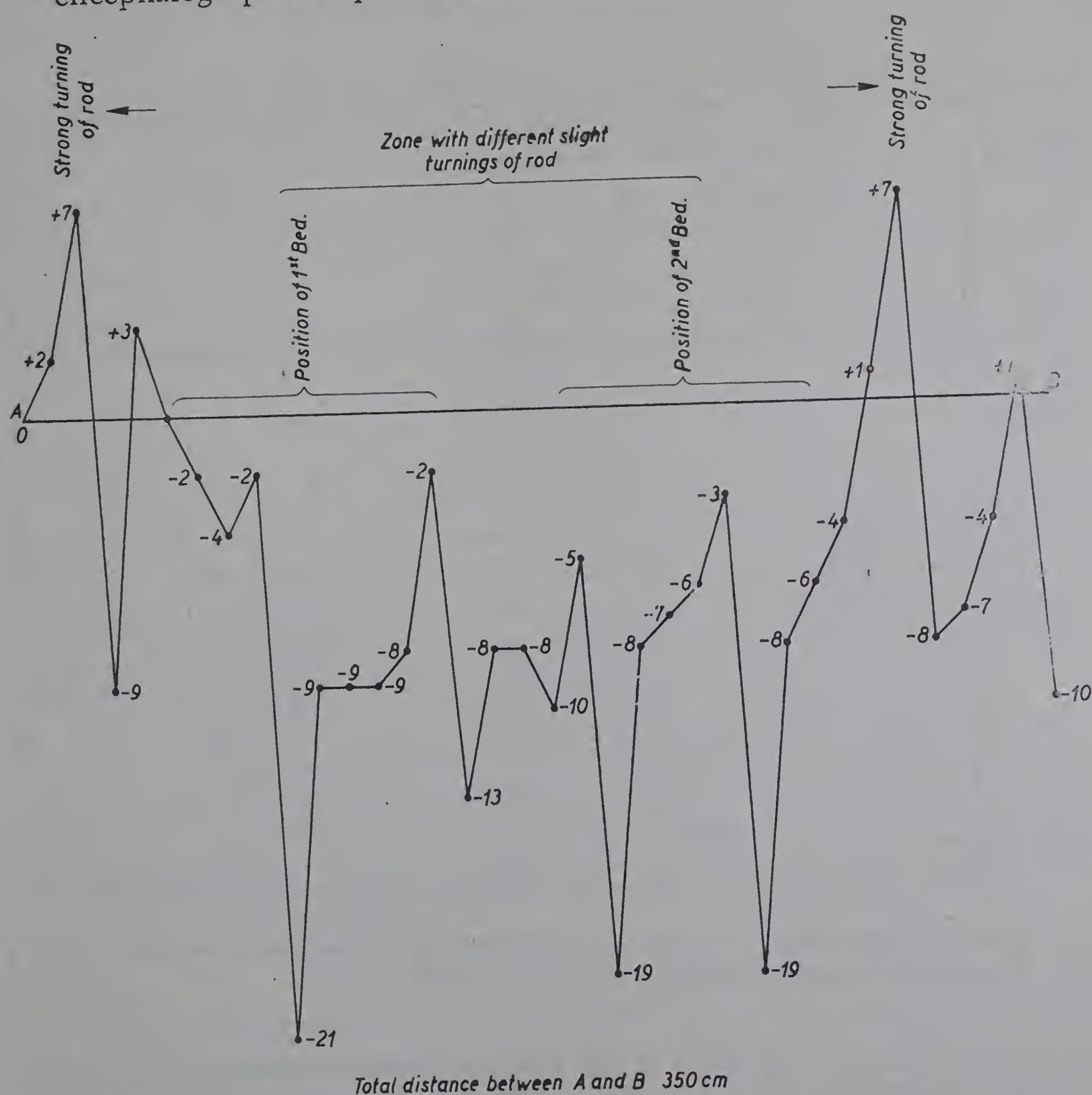

Fig. 98: Relationship between magnetic anomalies and dowser reactions in a room with two wooden beds with metal frames.

5. A. 3. Experiments on sensitivity to local disturbances of the earth magnetic field

We mentioned on p. 301 that local dowsing reactions in houses are observed, which in the case of weak turning (or rotations) seem to be due

to water pipes, central heating pipes, reinforced concrete beams, etc. It was found that considerable deviations of the magnetic needle of an ordinary geological compass could be observed above those places previously indicated by dowsers. Deviations of up to 30° are not uncommon in houses. As those dowsing zones could be found by dowsers before any magnetic measurement was done, any possibility of auto suggestion can be excluded. The deviation of the needle generally decreases rapidly at a certain distance above the floor; e.g., in the case of 30° deviation caused by an iron beam in a house, the deviation was only 15° at a distance

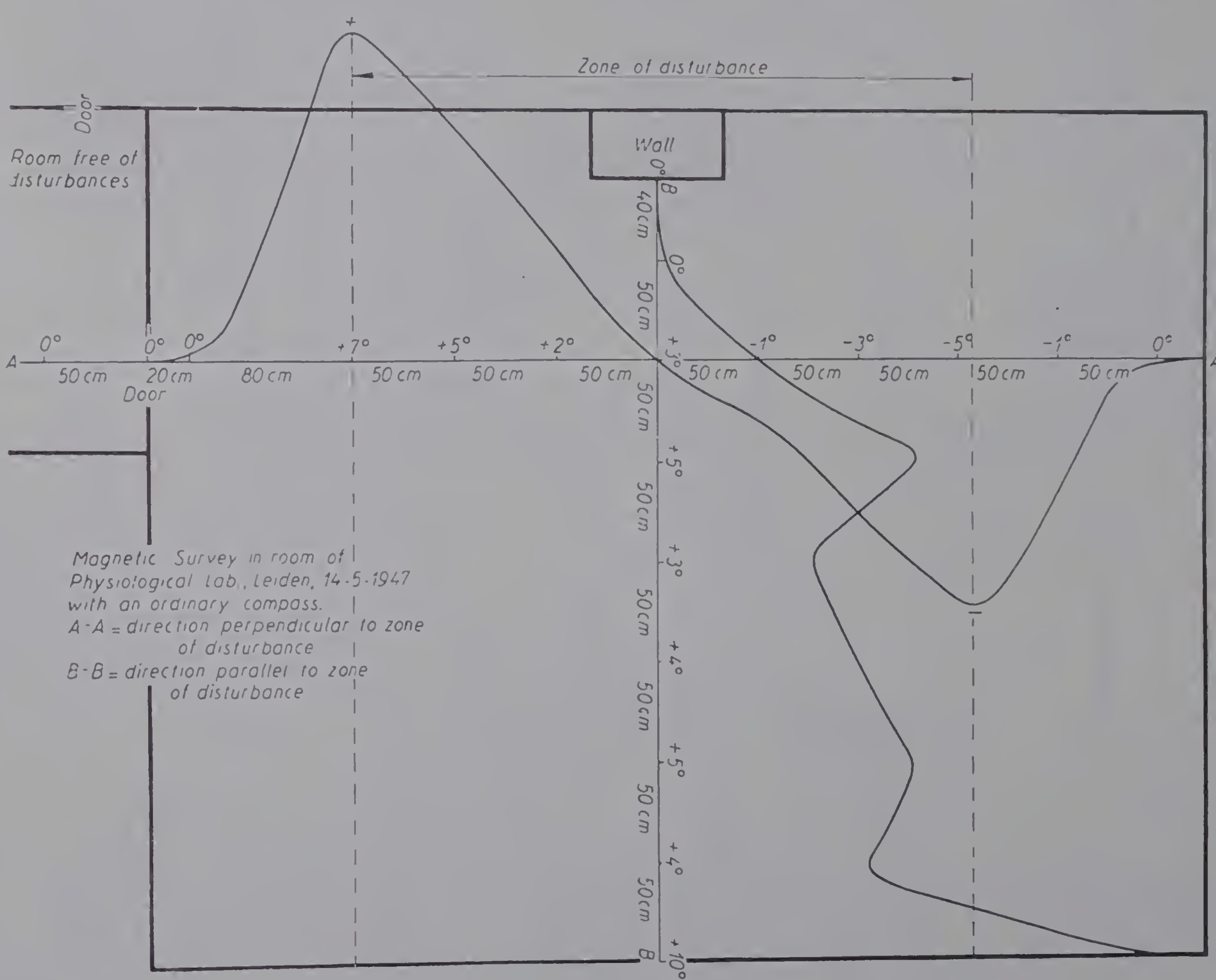

Fig. 99: Relationship between magnetic anomalies and dowser reactions in a room of the Physiological Laboratory in Leiden (Holland).

of about 30 cm. At the level of the arms of a person holding a divining rod, the needle no longer deviates. This at the same time shows the enormous sensitivity of our muscular nerves to these zones of magnetic disturbance and the difficulty of simply replacing the rod by a compass of average sensitivity.

A great number of such experiments have been carried out in which the dowser, walking along a straight line first indicated the dowsing zones (a corridor or room must be used without any surface pipes). A magnetic survey was afterwards made along the same line with an

ordinary compass and most striking results were obtained. Three experiments are represented in figs 97, 98 and 99. In fig. 97 the corridor is situated in an old deserted part of the physiological laboratory in Amsterdam. No pipes could be seen in the corridor and nobody in the building knew that there were water pipes behind the wall. After both dowsing and magnetic experiments were completed the wall was opened up and the position of pipes was found as indicated in fig. 97.

Fig. 98 is a good example of disturbances created by two wooden beds with iron mattresses; these were observed first with the rod and later measured with the compass. Fluctuations of the needle registered up to 28°

Fig. 99 is particularly interesting because the magnetic survey was made in a room of the physiological laboratory at Leiden a long time after the experiments with the string galvanometer, which we have discussed above, were concluded. In the curve above the line A A (called in our experiment "direction perpendicular to the zone of disturbance") it is not the absolute values of the position of the needle in degrees that have been plotted, but the differences in angle with a certain fixed azimuth of the compass needle at the door. The curve is similar to the dotted curve in fig. 47, upper row, $\alpha = 90°$. Although the curve in fig. 99 A A does not exactly represent the variations in the horizontal intensity, it gives a fairly good idea of these relations in the room. It is also interesting that this dowsing zone, which could also be observed one floor below the room, appeared to be caused by a large reinforced concrete drain pipe in the basement. In section B B, the gradient towards the place indicated in fig. 99 as "wall" is also remarkable. A similar effect was observed by the dowser and showed up also in the electrocardiograms (see for example right part of fig. 107, page 410).

These observations give further support to the statements made in sub 2 "Experiments with string-galvanometers", not only in themselves, but in the fact that they were carried out much later. This is because at the time of the experiments with the string-galvanometer we did not expect that the magnetic disturbances could be measured with an ordinary compass.

Strong dowsing zones in houses, which can be followed over long distances in the open air, cannot be found with an ordinary compass. This is not surprising as the source of disturbance in this case lies relatively deep. We have mentioned the case of a 30° deviation created by a beam, which can no longer be registered with an ordinary compass 150 cm above the floor. Another reason, which we discuss later, is the fact that those dowsing zones in the open air often are not due to magnetic disturbances but to electric effects of the atmosphere and soil.

5. A. 4. Experiments on sensivity to electric fields

In the Laboratory of Technical Physics in Delft and also in Leiden, experiments were carried out with very weak electric currents and

electro-static charges. The main results can be summarized as follows:

a. Small electrostatic charges brought artificially to the rod cause a muscular contraction and turning of the rod if the body of the dowser is insulated. A 4.5 volt pocket battery connected to two spots on the skin creates a turning of the rod irrespective of the place of attachment of the electrodes (the dowser standing on insulated shoes).
b. Only the latent period between the moment the electro-static charge was brought to the rod or the current switched on and the first observable reaction varies with the placing of the electrodes.
c. If the electrodes are placed symmetrically (e.g., on the left and right shoulder) practically no turning is observed.
d. The neighbourhood of electrostatically charged bodies without contact can also be registered by a diviner (through induction).
e. The latent period, after contact with an electro-statically charged plate, is in general less with small than with very big charges. A plate connected to a 5-volt dashboard caused turning of the rod after 5 sec, 50 V after 16 sec, 100 V after 22 sec.
f. Charging the rod with a comb (combed first through the hair) or moving of the arm of an observer below the arms of a diviner holding a rod causes a turning of the rod after a few seconds. In the latter event the reaction is apparently caused by friction electricity (see p. 175, experiments of OPPENHEIM).
g. The direction of turning of the rod in exp. a) with a 4.5-volt pocket battery differs with the direction of the current and the placing of the electrodes with respect to the axis of symmetry in the body.

With trial persons at our disposal the following observations were made:
If the *negative pole* makes contact with the big toe of the right foot, the left side of the loop-shaped rod comes up after a few seconds; if in contact with the big toe of the left foot, the right-hand side comes up (see fig. 87).
If the *positive pole* is in contact with the big toe of the right foot, the right side of the rod comes up; if in contact with the left foot, the left side comes up.
If the *negative pole* is in contact with the left-hand grip of the loop-shaped rod, the right-hand side comes up, if in contact with the right grip the left side of the rod comes up.
If the *positive pole* is in contact with the left-hand grip, the left side of the rod comes up, if in contact with the right-hand grip, the right-hand side comes up.

The results in a, d, and g could be confirmed if the electric contacts were laid first and if, without knowledge of the dowser, the circuit with a pocket battery was restored.

This fourth evidence for the reality of divining phenomena is not surprising considering the experiments discussed on p. 122 (exp. of GENGERELLI and HOLTER), on p. 182 (medical treatment with static electricity) and other electro-static experiments, (see p. 254-264).

These four different types of experiments have given sufficient evidence for our previous statement that dowsing phenomena really exist and are not the result of suggestion. This does not imply that suggestion cannot create similar phenomena, but the real dowsing phenomena occur independent of suggestion, the poor results often obtained during

critical tests of dowsers being only due to the reasons mentioned on p. 2 and 359-360.

The precautionary measures to be taken during dowsing observations are discussed on p. 360. They are not more complicated than those required for any geophysical survey. However, it is the fault of the dowsers themselves in that they claim to determine a certain locality for water or ore deposit by simply observing the reactions of the divining rod at a particular place, without taking into consideration the different geophysical reductions, required if a geophysical survey is to be a success.

We shall now discuss in greater detail the experiments with artificial magnetic fields and with the string galvanometer.

Experiments with artificial magnetic fields:

In these experiments a loop-shaped metal rod was used as represented in figs 86 and 87. The main results can be summarized as follows:

1. If a dowser stands in front of the tangent galvanometer (see fig. 96) and we connect the galvanometer with an electric switchboard, the first reaction can be noticed after a few seconds. This interval varies with different persons, depending on their sensitivity and the degree of insulation of their footwear. Using rubber shoes it usually takes about 5 seconds before the first reaction is felt, if the forearm muscles are considerably strained. If they are slightly strained it takes abt. 11 seconds. After previous washing of the hands with water it takes only a few seconds.
2. During the experiments with the tangent galvanometer it was often noticed that care is needed in not placing a person in the bundle of the lines of force in front of the galvanometer. At a distance of 2 metres from the galvanometer, for example, the magnetic field is hardly noticed if three men stand in front of it. Each human being seems to cause a local disturbance in a magnetic field.
3. If the dowser is blindfolded in front of the galvanometer and we move the ring of the galvanometer down or up (in other words the lines of force will be either vertical i.e., parallel to the dowser, ring of the galvanometer horizontal, or horizontal, i.e., perpendicular to the axis of the trial person, ring vertical) the dowser is able to feel the changes in the field strength. These experiments have to be carried out very carefully, otherwise there might easily be apparent failure. The following test demonstrates this clearly. The dowser was blindfolded (date of experiment September 12th, 1946).
The ring of the galvanometer was either vertical (lines of force cross the trial person) or horizontal (lines of force parallel the trial person), with a constant current of 10 ampères in the coil. The observers announced each time when the new experiment started. The dowser announced what he felt.

Experiment	a.	ring	was brought from a hor. into a vert. position	Result:	trial person felt a reaction
,,	b.	,,	remained vertical	,,	no reaction
,,	c.	,,	remained vertical	,,	no reaction
,,	d.	,,	was brought from a vert. into a hor. position	,,	a reaction
,,	e.	,,	was brought from a hor. into a vert. position	,,	a reaction
,,	f.	,,	remained vert. Interval between exp. 5 and 6 was only a few seconds	,,	a reaction
,,	g.	,,	remained vertical	,,	no reaction
,,	h.	,,	was brought first quickly in a hor. and again in a vert. position	,,	a reaction
,,	i.	,,	remained vertical	,,	no reaction

In experiments b and c one would expect the dowser to feel a reaction because the lines of force were crossing his body. However, there was no change in the field strength; apart from this the dowser always brought the divining rod to a stable position before the new experiment started, i.e., the muscular strain was adapted to the condition of the surrounding field. Only a changing field could turn the wire. This latter phenomenon should never be overlooked. If the grip in the hands is made strong enough it is impossible for the wire to turn. In other words the rod must be placed between the hands of the dowser in an unstable position outside any zone of disturbance of the magnetic field. If one starts in a position of equilibrium in the field itself it is very difficult to feel any weaker gradients.
In experiments d and e the person again felt the change in gradient. In experiment d the observer would expect "no influence" whereas the trial person felt a reaction. Mistakenly the experiment could be considered to be a failure. However if the dowser could bring the wire in a new position of equilibrium he would say "no reaction." The same wrong interpretation might be obtained if experiment e is carried out too quickly. The observer would expect "lines of force to be felt". The dowser feels the reaction only after 5 seconds or more. If he is forced to give an immediate reply as soon as the experiment starts his answer is negative; after 5-10 seconds it is positive. This brings us to another cause of so-called failures.

4. During the experiments we noticed clearly the *phenomenon of muscular fatigue*. If a trial person is tested for a longer period (e.g., 20 times or more) he can no longer register correctly. In one particular case, after 20 experiments the remaining answers were wrong. One should always allow short periods of rest to the arm muscles of the diviner between the different experiments. The phenomena

"muscular fatigue" and "slow reaction speed of the muscles" (see exp. 1) force the observer to be careful when testing a dowser.

5. Two other kinds of experiments with blindfolded people were made:

   a. The dowser starts outside the bundle of lines of force of the tangent galvanometer. He is blindfolded and walks slowly perpendicularly to the axis of the ring of the galvanometer (parallel to the ring itself). The observer switches the current on or off, unbeknown to the trial person (who is blindfolded and has cottonwool in the ears; the switch is noiseless). In general the first five experiments are successful but gradually more and more errors are observed and after 20 experiments they are very high. During the first 20 experiments 80% of the outcome is correct. This is considerably higher than ordinary guessing which is usually 50% correct. The 20% errors are partly due to slow reaction speed (i.e., during the next experiment the previous reaction is still working) and partly to muscular fatigue after the first 5 experiments. A certain percentage is due to lack of coordination between the nerve stimulation and the muscular contraction.

   b. Better results (i.e., more than 80% of the observations being correct) are obtained if the current remains constant, the angle of the ring of the galvanometer only being changed. The dowser walks blindfolded along the ring without knowing whether the ring is vertical or horizontal. Particularly good results were obtained when the ring was horizontal and brought up suddenly at the moment the trial person passes the ring. 100% correct result were only obtained with one particular dowser (Mr J.) The changing of the ring position could not be heard or felt.

6. It was possible also to trace the shape of the bundle of the lines of force with the rod by walking parallel to the ring of the galvanometer (i.e., perpendicularly to the axis). The diameter near the ring was abt. 130 cm; at a distance of 230 cm from the ring abt. 350 cm. According to the formula $H = 2\pi i \times \frac{R^2}{\sqrt{R^2 + a^2}^{\,3}}$ Gauss (in which H = field strength, i = strength of the current = 10 A, R = radius of the tangent galvanometer = 50 cm, a = distance of the ring) the field strength on the axis at a distance of 230 cm amounts to 0.001 Gauss. In the centre of the galvanometer it is 0.125 Gauss (the horizontal component of the earth magnetic field strength in Holland being abt. 0.184 Gauss in 1920). As the influence of the lines of force could be felt even more distant than 230 cm from the ring, the sensitivity of the average dowser is probably such that variations in field strength of less than one milligauss (0.001 Gauss) can be felt. Our exact limit of sensitivity is difficult to determine as it is not

so much the actual field strength that influences our muscular nerves as the gradient, in other words the change in field strength from 0.125 to 0.001 Gauss at a distance of 230 cm, i.e., 0.001 Gauss per 2 cm.

7. Two remarkable features were observed during the determination of the shape of the bundle of the lines of force:

   a. The dowsing reactions did not change if the current in the tangent galvanometer was increased or decreased. This supported previous observations that a dowser mainly observes the variations of the field strength and not its absolute values. From the previously mentioned formula it is clear that H in each point will become two or three times bigger but the gradient ratio does not change and this apparently determines the magnetic tension which is registered.

   b. If a dowser approaches the bundle of the lines of force he feels the first reaction at a certain moment. If he moves backwards and starts again he feels the reaction earlier. This can be repeated a few times but after the fourth or fifth time the reaction generally remains constant. This final point is different, however, depending on whether his muscles are strongly or only slightly strained. At a distance of 230 cm from the ring for example a diameter of the bundle of 280 cm, was measured with contracted muscles; after the fourth trial the distance remained constant at 390 cm. With slightly strained muscles the diameter increased from 246 cm to 325 cm. These figures show that a more sensitive reaction is felt with strongly strained arm muscles. This phenomenon of increasing sensitivity is probably related to the phenomenon described in experiment 1, indicating that a certain period is required before our muscles can register the variations of the field strength (see also p. 165, laws of muscular excitation).

8. If the direction of the current in the galvanometer is turned, the same results are obtained. This again indicates that only the gradient-ratio of the field strength and the direction of the gradient are registered. But as neither factor changes in the bundle of lines of force if the current is changed (only the direction of the magnetic forces along the lines of force changes) the dowser does not notice any difference in the dowsing reaction.

9. Several dowsers have one constant reaction if they enter a magnetic field; either the left- or the right-hand side comes up. However, most dowsers feel different reactions, depending on whether the cause of the magnetic disturbance is on the left or right side. The side nearest to the source is always inclined to move downwards. In other words, if the dowser moves along the ring of the galvanometer with the left side nearest to the ring, the left hand moves downwards and the right hand upwards (see fig. 87). If he starts from the other side the opposite reaction takes place.

10. If the dowser moves along the axis of the bundle of the lines of force

towards the ring, the rod will move downwards; in the opposite direction it will move upwards. Here again the dowser registers the change in field strength.

11. The sensitivity of the same dowser varies with his personal condition. We observed a difference between early morning (9 o'clock) and early afternoon (2 o'clock). Variations in the sensitivity before and after meals are also noticeable; alcoholic drinks considerably decrease the sensitivity.
12. If the tangent galvanometer is placed on the floor to the right side of the dowser and the dowser moves slowly with his chest parallel to the axis of the ring (feet and arms perpendicular to the axis) the loop-shaped rod turns and the right hand moves downwards. Above the ring of the galvanometer the wire turns back again into a horizontal position and the left side turns down as soon as the ring is on his left side.

Experiments with a string galvanometer of EINTHOVEN:

The experiments were carried out in a room of the Physiological Laboratory in Leiden, represented in fig. 99. A zone of disturbance occurred of abt. 2 m wide, the axis of the zone being the line BB in fig. 99. In this zone, walking along the axis, an increased turning of the rod was observed if the dowser moved towards the "wall" (see fig. 99). The small room was free of dowsing zones and had been used for experiments above human beings. Altogether 500 experiments were carried out covered by 130 photographs, the most important being reproduced in figs 101-150.

Four groups of experiments were carried out with the string galvanometer of EINTHOVEN: 1. a dowser walking through a dowsing zone; 2. a dowser walking along human beings; 3. a dowser walking along a tangent galvanometer (see fig. 96); 4. a dowser sitting in a moving car.

1. *Dowser walking through a dowsing zone*

If a dowser keeps the divining rod in loose insulated grips and he crosses a zone (fig. 99, line AA) which would normally cause the rod to turn, the rod does not turn, because of the loose insulated grips (if the insulators were immovably fixed turning would occur, see later). However, if during the movements of the dowser, both ends of the loop-shaped rod (see fig. 86) above the insulated grips are connected to the electrodes of the string galvanometer, no changes in electric potentials in the circuit are registered, i.e., the induction potentials created by the magnetic field of the earth are less than 0.1 mV; this could also be expected on theoretical grounds. As soon as we connect the electrodes of the string galvanometer to the divining rod and the arms of the dowser (see fig. 100) a complicated diagram is obtained. On p. 313 we mentioned that in order to analyse the different diagrams a few

basic experiments were first made, represented in figs 101-103*. After it was learnt that neither the particular circuit of fig. 100, nor slow walking in itself or movements of the electrode wires influence the electro-cardiograms, the actual experiments started:

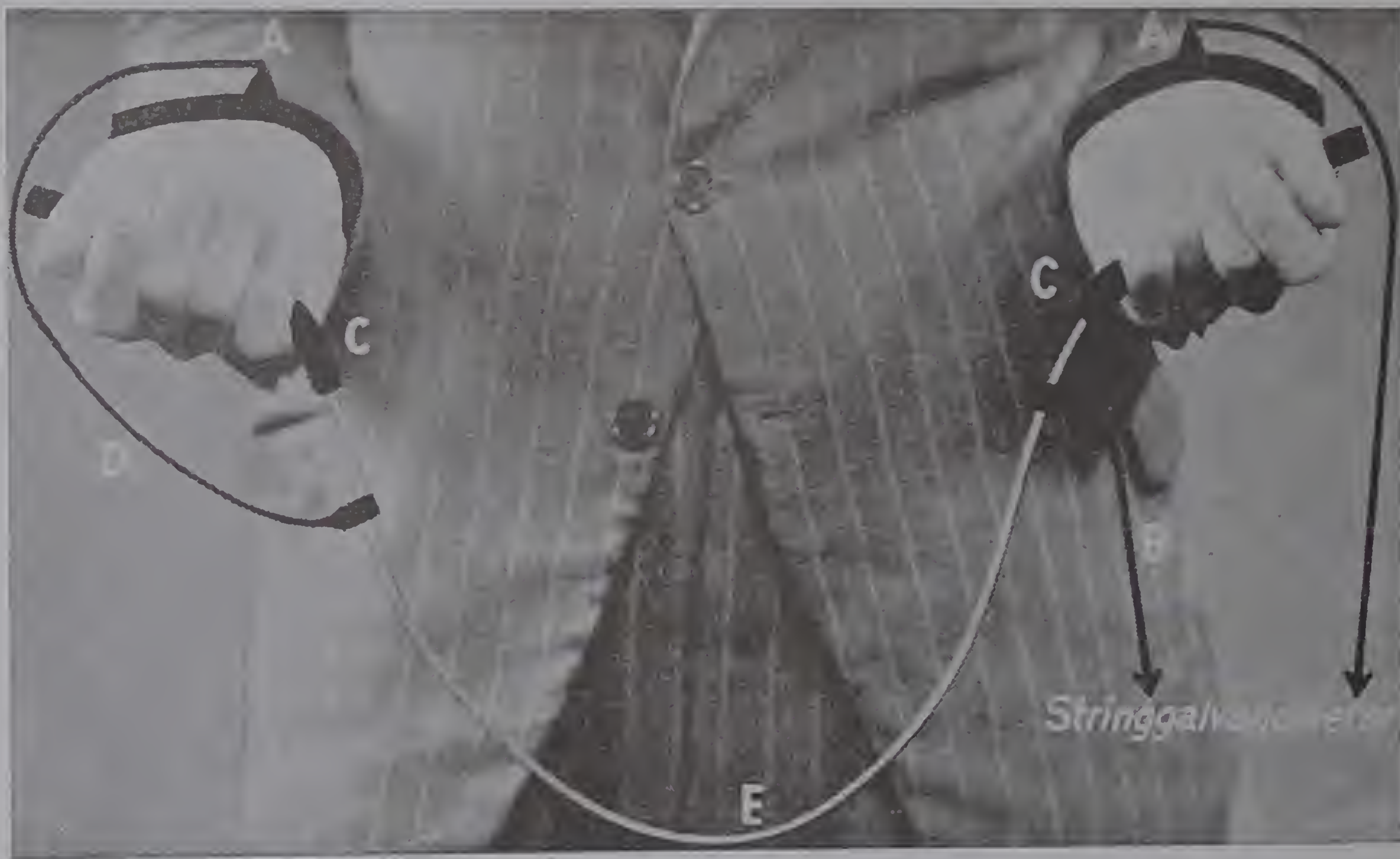

Fig. 100: Measurement of fluctuations in skin potentials of a dowser with a string galvanometer of EINTHOVEN (see also p. 144).

A. Metal grip attached to the skin of the pulse; between the grip and the skin is a paste mixture of pumice and salt.

B. Normal electrode wires (connected to a string galvanometer of EINTHOVEN).

C. Insulated grips.

D. Copper wire.

1. It was found that the experiment described in fig. 103 was different in the dowsing zone and outside it. Outside the zone of disturbance near the door of the large room (see fig. 99) all the Q-peaks of the electro-cardiogram remained sharply on the same level (see fig. 103); in the dowsing zone at the crossing point of line AA and BB all the Q-peaks were gradually rising (see fig. 104). If the electro-cardiogram is immediately afterwards measured outside the zone of disturbance the Q-peaks are on the same level again. This shows that the dowsing zone influences our skin-potentials. It does not, however, influence the type of diagram as such. The heart frequency or the height of the peaks do not change (at least with the trial persons at our disposal).

* For Figs 101—150, see pages 407—431.

After this experiment the following series of tests were carried out:

2. a. The dowser stood outside the zone of disturbance without moving his body. The electrodes of the galvanometer were connected to the left-hand pulse and to the divining rod, as in fig. 100. The grips of the divining rod were insulated in order to prevent any turning of the wire.

b. The dowser moved slowly and perpendicularly to the zone of disturbance (along the line AA) towards the centre of the zone. The moment the dowser entered the zone of disturbance, passed the spot of maximal disturbance and left the zone were registered with a chronometer. During this experiment the rod did not turn, because of the insulated grips. The type of electro-cardiogram during this experiment is indicated in figs 106 and 108.

3. The same experiment was made moving in the zone of disturbance parallel to the axis of disturbance towards the spot of maximal disturbance. The divining rod and the arms remained perpendicular to the axis of the zone during this experiment. The rod did not turn because of the insulated grips. The registered diagram is represented in figs 107 and 109. The diagrams of figs 106 and 107 indicate considerable changes in the skin potentials when a dowser moves through a dowsing zone, the changes being different for a dowser moving perpendicularly or parallel to the axis of the dowsing zone. This is further support for the statement that an ordinary psycho-galvanic reflex is not the cause of these diagrams, as in that case similar curves would be obtained in both instances. It is also remarkable that the gradient of the field strength along the line BB that can be observed with a divining rod and an ordinary compass shows up also in the high peaks at the right side of fig. 107.

4. a. The type of diagram observed in figs 106 and 107 always appeared in the zone of disturbance (see fig. 99) unless the dowser was very tired or if his shoes were wet.

b. It never appeared in another room of the laboratory where a narrow dowsing zone occurs above a bundle of copper wires in the floor and where no magnetic deviation could be measured (the measurement being done much later and the result of which was not known to the dowser at the time of the experiments).

5. In order to study the significance of the rod during the dowsing reactions, the experiments indicated in figs. 110, 111, 112, 113 and 114 were carried out; the results supported the fact, known to all dowsers, that neither the material of the rod, nor the rod itself are important factors in the dowsing process. The cardiograms, being the same as in figs 106 and 107, clearly demonstrated that the rod is merely an indicator for muscular contractions. In fact any kind of metal conductor can be used as a divining rod; also non-conducting flexible wires or needles, particularly the fork-shaped type of rod (e.g., two non-metallic knitting needles or two pieces of whale baleen connected at the ends with

a rubber ring). The sensitivity, however, is generally greater with a conducting metal rod. Therefore the influence of insulated grips is not observable if the grips are immovably connected to a conductor. Turning can only be prevented by using loose separate handles (at least with the dowsers at our disposal).

6. People non-sensitive to dowsing show in the electro-cardiograms a considerable change in skin potentials if they move through a dowsing zone. This is demonstrated in figs 115, 116, 117, 118, 119 and 120. In these experiments the subsidence of the curves is less sudden and the total change in skin potential is smaller than with sensitive dowsers.

2. *Dowser walking along human beings*

The experiments were carried out in the small annexe to the room of the previous experiments (see fig. 99):

1. Before the actual experiments started above persons lying on a rolling table, the experiments of figs 121 and 122 were carried out.

2. Immediately afterwards a male lay down on the rolling table and the dowser moved along this person. The results are shown in figs 123 and 124, and indicate considerable excursions of the string, particularly near the head. Experiment 124 was repeated; this time the dowser did not move but the trial person with the table was moved towards the dowser. The result of this experiment is shown in fig. 125. Figs 126 and 127 represent the same experiments as figs. 123 and 124, but were made a week earlier. Above a female person an irregular curve was also obtained (see fig. 128), although more regular than with the male trial person Mr v. d. S.

3. It was noticed several times that the moment the rod was placed above the body of a person lying on a table a sudden rise or lowering of the general level of the electro-cardiogram could be observed. In order to study this phenomenon a series of experiments was carried out (see figs 129-138).

These experiments indicated:

a. a sudden change of the skin potentials of the dowser if he approached a human body;
b. changes were different above the feet and head of a trial person, indicating a polarity of the human body;
c. changes were different for male and female persons.

4. If a person walks around a dowser and at the same time an electro-cardiogram is measured of the dowser (current similar to fig. 100) the Q-peaks rise slowly and a diagram is obtained similar to fig. 104. If the trial person stops walking around the dowser and the rod is momentarily earthed, the electro-cardiogram becomes normal again (similar to fig. 103). This experiment was carried out in order to test the claim of dowsers that they lose a great deal of their sensitivity if another person walks around them before the experiment starts. During our experiments

we found that this period of decreased sensitivity disappeared when the rod was momentarily earthed.

3. *Dowser walking through artificial magnetic fields*

If a dowser, connected to a string galvanometer as described in fig. 100, moves along a tangent galvanometer which is creating a magnetic field (see fig. 96), or if a field is suddenly developed while he is standing in front of the ring, a change in skin potentials can be registered almost immediately. This change in electric potential can amount to about 3.5 m.V. and is not observed if only the rod, kept in insulated grips, is placed in front of the ring and connected directly to the electrodes of the string galvanometer; in other words, the induction potentials in the conducting wire, created directly by the magnetic field in the rod, are less than 0.1 m.Volt.

The results of our experiments are shown in figs 139, 140, 141 and 142.

4. *Experiments with a dowser in a moving automobile*

Figs 143 and 144 indicate that the movements of the car in itself do not seem to influence the electro-cardiogram. As soon as the car entered the neighbourhood of strong dowsing zones, curves were obtained as indicated in figs 145-150.

Apart from the magnetic and electro-static experiments and those with string galvanometers, which were mainly carried out for the purpose of establishing the reality of dowsing phenomena, a number of other experiments were made in order to study the deeper causes of the physiological processes of dowsing. A short summary of the experiments is given here.

Influence of the muscular strain:

It was found that the more the arm muscles are strained, the more sensitive the dowser becomes. For this reason the kind of grip, in which the palm of the hand is placed uppermost (see figs 84 and 86), is usually the most sensitive for a dowser. In this connection it is interesting to mention the observation of Prof. SOMMER, a psychologist of the University of GIESZEN (Germany), who studied the changes in muscular tonus of the forearm of dowsers during a Dowsing Congress at Nauheim (Germany). The changes always occurred before the rod started to turn, indicating that the change in muscular tonus is the cause of the rotation of the rod and not a consequence of the turning.

nfluence of the conductivity of the skin:

a. If a dowser washes his hands with water (preferably hot), a salt solution or a diluted solution of sulphuric acid, his sensitivity usually

increases enormously. A great number of non-sensitive people could be made sensitive for a short period by washing the palm of the hand (which with these people is usually dry and smooth) with an electrolyte or even with water only.

b. It was found that the electric resistance between the centre of the left and right palm, measured with a direct current of 4.5 volt and electrodes of 3 mm diameter (see also p. 185) is less than 50,000 ohm with sensitive people, after washing their hands abt. 10,000 ohm or even less. Non-sensitive people often show values of 500,000 up to 3,000,000 ohm. Even after washing the hands, the resistance does not drop below 50,000 ohm.

The influence of the moisture content of the skin is indicated by the following values measured on a particular day: wet hands 15,000 ohm; quickly dried 22,000 ohm; thoroughly dried with a towel 38,000 ohm; dried above a radiator 50,000 ohm.

Although the skin resistance fluctuates considerably (see p. 185) the order of magnitude does not normally change within an hour if a person remains quietly in the same room. The skin resistance during the experiments with a string galvanometer amounted to 1,000 ohm, which remained practically constant (for at least two hours).

Apart from the fluctuations caused by changes in moisture, salt content and temperature, the skin resistance varies during the day and with the period of the year (see p. 185).

If the skin resistances are measured with alternating currents the absolute values are considerably less than indicated above, but the ratios remain the same. The fingertips usually have smaller resistances than other parts of the hand; the centre part of the palm (below the little finger and between thumb and index finger) is the best conducting part of the hand, the maximum value being in the centre of this zone at the crossing point of the line E and G in fig. 25. In this connection it is interesting to compare these observations with those in fig. 37.

It was found that the resistance of the sole of the foot is usually very high, i.e., $> 10^6$ ohm.

During our experiments we noticed that many so-called non-sensitive people do not hold the rod correctly. The grip is either too strong or not strong enough. If the grip is correct and the skin resistance low enough we are inclined to believe that more than 50% of man are sensitive to dowsing phenomena.

Influence of the electric contact between dowser and soil:

a. The sensitivity usually increases with higher insulation qualities of the footwear (e.g., thick rubber soles); walking without shoes usually decreases the sensitivity. Exceptions to this rule were observed with highly strung dowsers; this seems to be the result of non-electric phenomena, such as presence of volatile components, etc. (see later), which in that case are the cause of the dowsing phenomena.

b. Very wet soil or wet snow cover usually decreases considerably the sensitivity of the dowser; the dowsing reactions above places where normally strong turnings of the rod are observed might even be completely be lacking.

c. Connection of a thin copper wire to one of the sides of the rod and to the earth usually prevents the turning. Experiments with the string galvanometer indicate that in this case no permanent changes in the skin potentials are created.

Influence of speed:

It was found that the faster the dowser moves the stronger is the dowsing reaction. However, in order to determine the exact boundary of a dowsing zone the dowser must walk slowly and repeat the experiment 7 b described on p. 322.

Direction of turning of the rod:

It has been found that, if a dowser moves along a certain line in two opposite directions successively, the rod usually turns in two different directions, e.g., in fig. 99, moving along the line AA from the door near the small room to the opposite wall, the right side of the loop-shaped rod came up near the line BB; walking in opposite direction the left side came up. The influence of electric charges on the direction of turning is discussed on p. 318, sub g, the influence of artificial magnetic fields on p. 322 (exp. 9 and 12). In general it seems that the side of the loop-shaped rod which is nearest to the source of disturbance moves downwards.

Influence of friction during walking:

Electric potentials up to 30 volt are quite common in the conducting rods as a result of the friction of the soles of the shoes. In very dry weather rubber soles can develop potentials up to 700 volt.

Influence of volatile components:

It was found that strong smelling substances create a similar dowsing reaction as an electric charge brought artificially to the rod. A dowser walking towards a place from which emanates a strong odour, notices a turning of the rod. If the experiment is repeated, with the dowser holding his breath, no turning of the rod occurs.

Influence of differential heating of the sun:

If both uncovered forearms of a dowser are more or less equally exposed to intensive sunshine no dowsing reaction occurs. If only one of the forearms is irradiated by sunshine and the other is covered or in the shade, a divining rod will turn after a few seconds in the hands of a dowser.

This summary of the main experiments on dowsing carried out by the author indicates that a great number of external forces can create dowsing phenomena. The results of the experiments of De Vita, Jemma, Maby, and Wüst, which we discuss in the following section, give further support to this statement.

B. Experiments of De Vita, Jemma, Maby, and Wüst

5. B. 1. *Experiments of* A. De Vita

In about 1933 De Vita (Bibl. No. 624 and 1330a) made some observations with electroscopes and electrometers, which indicated a greater degree of atmospheric ionization over dowsing zones, than over normal ground, irrespective of humidity. Maby later confirmed these observations (see figs 92, 93, 94). De Vita's observations were summarized by Maby as follows (Bibl. No. 1111, p. 107):

1. Electroscopes placed over underground streams discharge more rapidly than they do over normal ground of the same kind.
2. Such areas shift with the position of the sun, with atmospheric conditions, and sometimes disappear for considerable periods of time. Certain wind storms may also preclude reactivity.
3. Areas of ground giving rod and negative electroscopic reactions often coincide with galvanometric currents obtained between electodes in the adjacent soil.
4. First readings in a given locality are usually best and movements upset them. A rapid falling off of the electric potential difference is the best condition for observation.
5. Observations made near electric power cables are confused by sudden changes of electric potential and ionization of the air.
6. Electroscopes placed near trees, houses, water supplies, etc., show more rapid drop of potential, by discharge due to ionization effects, than do those on open ground under similar conditions of soil and air.

5. B. 2. *Experiments of* R. Jemma

R. Jemma (Bibl. No. 1011) confirmed the above-mentioned results. He discovered the following additional phenomena:

1. The sensitivity of a dowser varies during the day in relation to meteorological conditions and atmospheric electricity.
2. There are seasonal variations in the ionization, which seem to coincide with periods of sensitivity of the dowser; conditions are best in autumn and spring and worst in midsummer.
3. Variations are associated with altitude and position of the sun.
4. Low-lying (strato-nimbus) clouds reduce the dowsers reactions, whereas high (cirrus) clouds have no appreciable effect. Storm and thunderclouds may augment or diminish the electric and dowsing effects.

5. Sudden inversions of electric polarity sometimes occur beneath a clear sky and affect the results of dowsers.

6. Small trees may disturb the local electric fields more strongly than a large metal-roofed house or a metal conductor placed vertically in the soil.

5. B. 3. *Experiments of* J. C. Maby and T. B. Franklin

In their book, "The Physics of the Divining Rod" (1939), an extensive and most stimulating survey is given of a number of dowsing experiments carried out by different dowsers. A great number of experiments are described which were undertaken by the authors themselves. It is evident that a brief summary of their experiments, which cover almost 420 pages, cannot be given in a few paragraphs. We therefore highly recommend readers interested in dowsing to read the book. There are, however, a few shortcomings:

1. The book fails to give a scientific analysis of all the physiological processes responsible for dowsing; physiological problems are hardly touched upon.
2. The authors are convinced that one exciting force, the high frequency Hertzian waves, is mainly responsible for dowsing; as a result practically the whole book is devoted to the assembling of facts which prove their assumption; as a result they do not see the wood for the trees.
3. The geo-physical and mathematical considerations are not always correct, a conclusion not only based on the author's impression but confirmed by a number of prominent physicists and geophysicists.

However it would be a great injustice to reject all their ideas because of certain shortcomings in their book. The reading is highly recommended to any one seriously interested in this subject and we should be grateful for the enormous amount of research carried out by both authors.

Only three experiments are reviewed in the following pages:

a. Earth ray photographic tests
b. Estimation of depth
c. Relation between ionization and dowsing zones.

Sub a. *Earth-ray photographic tests:*

Dobler (Bibl. No. 850), and Beichl and Von Pohl (Bibl. No. 1190) claimed to have detected by photographic means a special radiation of the ground in relation to underground water, etc. Freshly polished strips of metal, such as aluminium and zinc, were laid in direct contact with unexposed photographic plates of medium sensitivity. The authors assumed that some penetrating radiation from the ground above underground streams, etc., would increase the effect of metals on a photographic plate. In fact

they produced a number of photographs which indicate this photographic effect.

Maby repeated these experiments in 1936 (see Bibl. No. 1106) and confirmed that the different metalstrips gave pronounced images on the photographic plates. The following results were also obtained:

1. the images are equally strong (if temperature and humidity are the same) over an underground stream or in an equivalent position clear of any stream.
2. the images are equally strong whether the plates be exposed horizontally or vertically with regard to the earth's surface and whether they are laid directly on the ground or on the third floor of a house.

Our previous discussions on p. 33-48 concerning the Russell-effect indicate that the above-mentioned experiments of Dobler and Von Pohl are worthless from the point of view of dowsing. We know that so many factors create this Russell effect that even if differences had been found by Maby, we would be more inclined to ascribe them to the influence of different external factors as reported by Russell. Maby's experiments are interesting from another point of view. They confirmed again the previous observations of Colson and Russell.

Sub b. *Estimation of depth:*

Dowsers in general (and also Maby) claim that it is possible for a dowser to estimate the depth, magnitude and yield of an underground stream. The expression "underground stream" indicates that most dowsers have only a vague idea of the geologic conditions in water bearing strata. In the summary of geophysical research methods (on p. 204) we have shown that not one single method has been successful in the correct estimation of depth, magnitude and yield. If conditions were so facile not a single dry oil or water well would any longer be drilled. Anybody conversant with exploration work knows too well that this happens quite often. Although the different recommended techniques might be useless as an accurate depthing method, some of the dowsers' observations are worth mentioning. Maby has given an excellent summary of their methods, so we shall restrict ourselves only to the main points. Maby described in Bibl. No. 1111 on p. 96-100 a number of popular dowsing methods used for depthing:

1. "The dowser holds his forked rod with a firm grip in both hands a little above his head and slowly lowers it down towards the ground, keeping the arms outstretched with as uniform tension as possible. If a reaction occurs at high level, then the objective is said to be only at slight depth below the ground; the more the rod has to be lowered before a reaction is obtained, the greater the depth in proportion."

2. "The dowser has to find first the exact vertical reaction plane through the hidden object, then, standing there and facing cross-wise, he has to take a standard grip on the rod and at the same instant he begins counting seconds. After a number of seconds the rod may turn which should be an indication for the depth."

3. The BISHOP's *rule:* This method assumes that a definite beam of earth rays strikes the surface of the earth at an angle of 45°, in other words at a distance equal to the depth. In order to use this method the dowser first determines the vertical reaction plane; then he walks away from it with his rod carefully set untill he experiences the "depth reaction", i.e., the end of the dowsing zone.

4. *Method of* PROBST: "The dowser is pegging first the dowsing zone; then a stout metal wire is laid out, clear of the ground, at right angles to the zone. The dowser walks with a rod along the wire and at certain distances definite rod reactions are observed. These distances should be equal or at least proportional to the depths below the ground of a horizontal bed."

5. *Point depthing method of* MAJ. R. CREYKE (1936):
CREYKE collaborated for a considerable time with MABY and FRANKLIN. CREYKE's method is described by MABY as follows: "The dowser spikes a vertical metal rod just inside the primary reaction zone; then he walks away from the rod approximately at right angles. At certain distances new circles of reaction are obtained. Sometimes several sharp reaction zones will follow one another. The distance of the first point from the vertical metal rod represents the depth of the object's top surface and the second that of the lower surface". Although CREYKE and MABY claim that very accurate results were obtained with shallow objects, we doubt the accuracy of the method. It is a kind of equipotential method and it is evident that the distribution of the equipotential surfaces is an indication for depthing, but a simple relation as indicated by these authors neglects again the complexity of sub-surface relations. CREYKE recommended as a vertical rod a very magnetically permeable alloy of iron. According to MABY, however, all kinds of metal give satisfactory results; the longer the metal rod stronger are the depth reactions. MABY also made some experiments with the flow of water in pipes. According to him *the reaction increases with the yield of water, irrespective of depth, until a certain critical value is reached.* He claims also that dowsers can determine the relative velocity of flowing underground water. However it is doubtful whether the latter claim is based on sufficient critical data.

This short summary indicates that a wide field of research lies ahead. It is particularly interesting to establish whether a dowser could be

used as a second electrode in the equipotential method (see p. 234), at the same time being the registering voltmeter or galvanometer. If this would be the case a simple but most interesting application might be found for a field geologist.

Sub c. *Relation between ionization and dowsing zones*

In 1935 MABY and FRANKLIN were able to confirm the observations of A. DE VITA and H. M. BUDGETT that the ionization rate over a dowsing zone is often very distinct from that over neutral ground a few metres on either side of the dowsing zone. MABY originally used an ionization counter, designed by Dr WYNN-WILLIAMS and manufactured by the Cambridge Instrument Co. in London. Sometimes the dowsing zone showed the greatest ionization, on other days the neutral zones gave the higher values.

In later years these studies were repeated with automatic neon tube recorders, taking 5-minute readings. MABY found that the ionization difference is not a consistent distinction and therefore the average over a long period shows no difference between a dowsing zone and the neutral bordering strips. Temporary distinctions can be very pronounced, however, as indicated in figs 92 and 93 (R-band = reaction zone, N-band = neutral zone). In fig. 94 MABY has shown schematically the relation between dowser's muscular strength, magnetic intensity, ionization rate, ground electric potential and radio reflection signals.

5. B. 4. Experiment of J. Wüst and J. Wimmer

In Bibl. No. 1370 and 1371 an extensive description can be found of the dowsing experiments of these authors. They tried to prove in about 1934 that dowsing is due to unknown waves of 1-70 cm wavelength, radiated by living and non-living objects. The experiments were carried out in the Anatomical Institute of the University of Münich by WÜST, a physico-chemist experienced in medical problems, and WIMMER, specialized in mathematical physics. WIMMER was at the same time gifted as a dowser; this created an ideal cooperation between both scientists. For many years their experiments have been copied, more or less blindly, by dowsers in different countries. Although many of their experiments have been confirmed by the author, a great number still await a scientific test before they can be accepted. We do not disagree so much with WÜST as far as the observations themselves are concerned, but the interpretation seems to be completely erroneous and more or less a result of wishful thinking. As we cannot review in a few pages the great number of experiments carried out by WÜST and WIMMER, we shall discuss only those which have been used by these scientists as evidence for their radiation theory. All experiments were made between 3 and 6 p.m., abt 3 times a week. WÜST always retested WIMMER after a few weeks on the same phenomena without WIMMER consciously realizing it.

TABLE II

Element	Rate of turning of rod in degrees	Diameter of diaphragm preventing turning of rod	Element	Rate of turning of rod in degrees	Diameter of diaphragm preventing turning of rod
H I	—90	0.2	Ca	360—370	3.3
H II	—90	0.3	Mn	390—410	3.3
H in			Fe R?	100—120	3.4
OH[1]	—90	0.45	Ge	810—830	3.7
N	120—140	0.55	Pd I	460—480	3.7
O I	90—110	0.6	Cr	320—340	3.8
			Fe	100—120	4.0
			Sn	290—310	4.0
C	40—50	0.7	Na	220—240	4.0
Ce I	410—420	0.75	Zn	260—280	4.2
B	30—50	0.8	Pb I	290—310	4.55
			Co	240—260	4.4
			(Ms Th?)	370—390	4.9
S	50—60	1.1	Cd II	390—410	5.0
Al	40—50	1.2	W	420—440	4.9
O_2	100—120	1.4	Sr	120—140	5.2
O_3	100—120	1.6	Pd II	460—480	5.3
Ag	210—220	1.6	Hg	390—410	5.3
Li	100—120	1.7	Cl III	280—300	5.3
F	70—80	1.7	Ba I	290—310	5.3
O_4	100—120	1.9	Ni	220—240	5.5
Cl I	280—300	1.9	Pb R?	290—310	5.8
Se	330—350	2.0	Bi	280—300	6.0
Au	230—240	2.0	U	390—410	6.1
Br I	420—440	2.1	Ce III	410—430	6.2
Cu	230—250	2.15	Ba II	290—310	6.2
Mg I	330—350	2.3	Bi R?	280—300	6.3
Te	380—400	2.4	K	740—760	6.4
Mg	330—350	2.5	Cs R?	600—620	6.6
Sn R?	290—310	2.5	Th	410—430	6.8
Ce II	410—430	2.5	Pb R?	290—310	6.9
J	300—320	2.7	Rb I	310—330	7.0
Be	50—60	2.8	Rb II	310—330	8.0
Cd I	390—410	2.8	O_2II	110—130	8.0
P	440—460	2.9	(Ra?)	320—340	8.1
Cl II	280—300	2.9	(Ac?)	460—480	8.8
Si	310—330	2.9	Cs I	600—620	9.3
Mo	400—420	2.9	Mg II	330—350	9.3
Pt	660—680	2.9	Ce IV	410—430	9.9
Ti	740—760	3.0	Cs II	600—620	10.0
Tl	320—340	3.1	Br II	420—440	10.3
As	320—340	3.0	(Eka Cs?)	410—430	13.1
Sb	370—390	3.1			

TABEL III

	I	II	III	IV	V	VI	VII	VIII
1 H −90°	3 Li 100—120°	4 Be 50—50°	5 B 30—50°	6 C 40—50°	7 N 120—140°	8 O 90—110°	9 F 70—80°	
	11 Na 220—240°	12 Mg 330—350°	13 Al 40—50°	14 Si 310—330°	15 P 440—460°	16 S 50—60°	17 Cl 280—300°	
	19 K 740—760°	20 Ca 360—370°		22 Ti 740—760°		24 Cr 320—340°	25 Mn 390—410°	26 Fe 100—120° 27 Co 240—260° 28 Ni 220—240°
	29 Cu 230—250°	30 Zn 260—280°		32 Ge 810—830°	33 As 320—340°	34 Se 330—350°	35 Br 420—440°	
	37 Rb 310—330°	38 Sr 120—140°				42 Mo 400—420°		46 Pd 460—480°
	47 Ag 210—230°	48 Cd 390—410°		50 Sn 290—310°	51 Sb 370—390°	52 Te 380—400°	53 J 300—320°	
	55 Cs 600—620°	56 Ba 290—310°		58 Ce 410—430°		74 W 420—440°		78 Pt 660—680°
	79 Au 230—250°	80 Hg 390—410°	81 Tl 320—340°	82 Pb 290—310°	83 Bi 280—300°			
	87 (Eka Cs?) 410—430°	88 (Ra?) 330—340°	89 (Ac?) 460—480°	90 Th 410—430°		92 U 390—410°		

Periodic system of MENDELEJEFF and rate of turning of divining rod

A 60 cm long, forked-shaped, 2 mm thick steel wire was used as a rod. The main results can be summarized as follows:

a. Certain substances, such as celluloid, bebrite, galalithe, silk, etc., placed between an object (which normally gives a dowsing reaction) and the dowser, prevent dowsing reactions. Two magnets placed at two opposite corners of a square perpendicular to one another (with opposite poles directed to each other) prevent the dowsing reaction above an object placed in the centre of the square.

b. The dowsing effect can be conducted along wires, through condensers, etc. The speed of transmission amounts to 42-45 m/sec.

c. All matter, living or non-living, creates a specific turning of the rod. In table II Wüst has indicated the rod turnings above different chemical elements, which were compiled in a Periodic system of Mendelejeff (see table III).

d. Wüst discovered that if a dowsing substance (e.g., a copper wire) was covered by another substance impermeable for dowsing (see sub a) and a small hole (diaphragm) of 0.5 mm made in this covering layer, and if a dowser approaches the object from a few metres distance, turnings of the rod seem to occur at regular intervals which according to Wüst and Wimmer indicate diffraction phenomena.
In table II, columns 3 and 6 the minimum diameter of the diaphragm in cm is shown which creates the dowsing effect (= $^1/_4\lambda$ of the wavelength of the "dowsing waves"). In other words, in the case of beryllium for example, the diaphragm should be wider than 2.8 cm, in order to create these diffraction phenomena.
Using these "diffraction" rings Wüst calculated the "wavelengths" for different elements. These varied between 0.9 cm (with H_1 in table II) and 52.4 cm (with Eka Cs); Te = 10 cm, Cd II = 20 cm, Rb_1 = 28 cm, Cs II = 40.2 cm. In fig. 95 Wüst has arranged the different elements according to their atom number and their "dowsing wavelength".

e. The *w-radiation* of Wüst (the name given because of the influence of the radiation on the "Wunschelrute" = divining rod) could also be reflected against smooth walls.

f. The dowser can sensitize himself for specific substances, also if the metals occur in chemical compounds both solid and fluid; concentrations of certain metals as small as 10^{-21} could be established by Wimmer.

g. Certain combinations of metals seem to prevent the dowsing effect, although the metals are separately pronounced "W-radiators".

h. The W-radiation could not be measured with ordinary physical instruments such as the vacuum tube amplifier, etc. The fact that it can penetrate through conductors, contrary to other electro-magnetic waves, is an indication, according to WÜST, that the W-radiation is a kind of "unknown vibrating magnetism" to which he gave the name *magnetoism*, the W-radiation itself being *magnetoidal vibrations*.

i. The W-radiation radiated by the human body was the same as WÜST observed above magnets.

This short review indicates that WÜST and WIMMER were so convinced that dowsing phenomena are due to radiations and not to "fields", that they have tried to explain all the observed facts with a physical, unmeasurable radiation. Although WÜST claims to have medical experience, the complete neglect of physiological processes in the body of the dowser demonstrates that both WÜST and WIMMER failed to visualize the complex muscular phenomena responsible for the dowsing effect. The phenomenon of different successive reactions, if a dowser moves in a disturbing electric, magnetic or electro-magnetic field, is a common feature and can easily be understood if the mechanism of muscular contraction and the relaxation due to external excitation are visualized.

It is possible that certain substances have a screening effect, but the observation that two magnets (exp. a) prevent a dowsing reaction is not due to the lack of excitation but to the fact that the influence of the magnets on the dowser is stronger than that of an object placed in the magnetic field (see also the author's experiments with artificial magnetic fields, sub 2, p. 319).

In section C (page 355) we give a summary of the different causes of the dowsing reaction. This shows that a dowser can register potential differences between the arm and neighbouring objects. The importance of the potential gradient in the atmosphere is also discussed. Depending on the conductivity and other electric properties of a non-living body the electric field (i.e., the electric lines of force) between the body and the dowser is different. The influence of a conductor might be screened off therefore by an insulator and a small hole in this screen could allow the electric lines of force to penetrate through the screen towards the conductor. The density of the bundle of lines of force is different at different places and depends on the distance between object and dowser and the physical properties of the object. It is feasible that these variations in the lines of force can be registered by a dowser, but it is highly improbable, particularly considering the other known dowsing phenomena, that these phenomena of WÜST are due to radiation. The fact that WÜST and WIMMER were forced to assume the presence of an unknown magnetoidal vibration supports our statement that ordinary radiation cannot explain the W-effect. Further evidence for our "field" theory is given in the following sections.

C. Synthesis of the physical and physiological processes creating dowsing phenomena

In order to analyse the possible causes of dowsing phenomena we must refer to the first part of the first chapter: *the organic field*.

If we try to find an explanation for the cause of the turning of the rod there seems to be no good reason to assume that the divining rod is turned in our hands by forces different from the muscular forces. The ordinary physical forces in the geophysical and meteorological field encountered by the dowsers are incapable of producing the great amount of energy required for a *direct turning of the rod.* It is therefore rather unscientific to insist on the existence of unknown supernatural forces so long as not the slighest evidence can be put forward to support such insistence. This view is strengthened when we remember that the physical forces in the world surrounding the human body are sufficiently large to cause a *turning of the rod indirectly*, i.e., by stimulating the muscular nerves of the arms holding the divining rod. We shall try to give an analysis of this process and of the different external forces responsible for the excitation of the muscular nerves.

Two fundamentally different processes can be thought of (see p. 165):

1. Direct stimulation of the motor nerves of the forearm (induction shock);
2. Indirect stimulation by a single volley of electric discharges in the motor nerves set up by the central nervous system as a result of the internal or external exciting forces.

It has been found that direct stimulation of the muscles by a current directly applied to the arm requires 1 mA or abt. 12 V if the arm is at rest, the person not insulated and the skin resistance brought down to abt. 1,000 ohm by washing the arm with a solution of an electrolyte.

The rheobase for myelinated nerves in vitro seems to be abt. 10^{-9} A; for unmyelinated nerves (sympathetic nervous system) 10^{-6}-10^{-7} A. For stimulating a muscle by the muscular bodies of the motor nerve an action current of 20-30 mV is required (see p. 136).

In order to judge whether direct or indirect stimulation is responsible for the muscular contraction during dowsing we must summarize first the different stimulating forces encountered in previous chapters and the amount of exciting energy released by each of those forces. We must then analyse how much of this energy reaches the nerves directly and how much is absorbed by our skin.

It seems preferable to give this summary of externally stimulating forces in the form of a table as the web of external forces influencing the human body is so complicated that an ordinary description would not permit the reader to obtain a clear picture of the whole dowsing process.

The externally stimulating forces can be divided into two groups:
1. Forces stimulating a dowser in the open air and near buildings;
2. Forces stimulating a dowser in houses.

These different forces (the mechanical ones being excluded) can be grouped under 5 headings:

A. Electric stimulation
B. Magnetic stimulation
C. Electro-magnetic stimulation
D. Acoustic stimulation
E. Stimulation by volatile components (chemical and electric stimulation).

In the table between brackets the number of the page has been indicated where the respective phenomena are described in greater detail.

(A) Electric stimulation

1. *Atmospheric fields:*

a. *Influence of aero-ionic currents:*

- α. Mechanism of ionic effect:
  1. direct stimulation of nerve endings in skin (p. 262): changing tactile reaction
  2. penetration of ions in lungs in the blood stream: absorption of all ions with charges opposite to the membrane charge (i.e., mainly negative ions). Influence of negative ionic current: decreasing respiration frequency, blood pressure; increasing sensitivity of nerves (p. 261-264).
- β. Cause of ionic fluctuations (p. 249)
  1. variations in cosmic radiations
  2. variations in Ra Em. content of soil (p. 238)
  3. fluctuations of potential gradient (in magnitude and sign)
  4. influence of equipotential lines on surface of the earth
  5. influence of humidity, temperature, atmospheric pressure
  6. presence of metal conductors increases number of pos. ions (p. 243)

b. *Influence of potential gradient:* average value 120-150 V/m (p. 247)

- α. Mechanism of gradient effect:
  1. living body earthed:
     a. GENGERELLI-HOLTER effect: direct electrostatic tension on nerves (p. 122)
     b. influence on aero-ionic currents
  2. living body insulated:
     a. effect due to potential difference between atm. pot. and self-pot. of the body
     b. influence on aero-ionic currents

β. Cause of fluctuations of gradients
1. Influence of topography (houses, trees, etc.)
2. influence of weather (p. 250):

clear air	— low gradient
fog	— high gradient
land rain	— negative gradient
thunderstorm	— high pos. and neg. gradients
snowfall	— high pos. and neg. gradients
above sea	— low gradient

3. influence of equipotential lines on surface of the earth (p. 227 and 233)
4. cosmic influences (p. 250-253)
   a. daily fluctuations: *over oceans and polar regions:*
      min. gr. : 107 V/M at 4 h Gr. M. T.
      max. gr. : 150 V/M at 19h Gr. M. T.
      average gr.: smallest from April-Sept.
      greatest from October-March
      over continental stations:
      (Northern hemisphere)
      summer: double oscillation (p. 252)
      winter: usually simple oscillation (electrode effect, p. 252)
   b. yearly fluctuations (p. 252):
      land stations: stations N of 30° N and S of 40° S:
      min. daily fl. July-Aug.
      max. daily fl. Nov.-Jan.
      between 30° N and 40° S:
      irregular fluctuations, only at most northern and southern places, oscillations of daily var.: max. in July-Aug., min. between Nov. and March
   c. eleven-year period: gradient incrasing 20% if sun spots increase 100%.

2. *Geophysical fields:*

a. *Influence of conductivity of soil:*

α. Mechanism of conductivity effect:
1. influence on electric discharge of living bodies
2. influence on potential gradient and earth currents

β. Cause of fluctuations of conductivity:
1. changes in rock composition (p. 225)
2. changes in water content
   a. due to atmospheric influences (precipitation, heat, bar. pressure)

b. due to changes in porosity and permeability
c. due to changes in soil structure (cleavage, etc.)

b. *Influence of earth currents* (equipotential surfaces, p. 227):

average pot. diff. up to 500-1000 mV/km

α. mechanism of earth-current effect:
influence of surface potential of earth
a. effecting electric discharge of living bodies
b. effecting pot. gradient of the atmosphere
c. effecting aero-ionic currents

β. Cause of fluctuations of surface potential: (p. 231-232):
1. geological causes:
a. local changes in composition of rocks
b. presence of good conductors (p. 229);
electrode distance (L) 〈 depth conductor (d):
penetration factor small
L slightly 〉 2d: max. penetration factor
L much 〉 2d: small penetration factor
c. geological structure: faults, folds, subterranean caves, ore bodies, stratification (anisotropic effect, p. 230)
d. ground water level: deep level and high surface resistivity give small surface pot.
e. distribution between land and water: influence on ground-water level, moisture content of rocks, shape of equipot. surfaces
f. topography: shift of "negative centre" downhill (p. 228)
g. regional gradient: 10-100 mV/km
2. atmospheric causes:
a. changes in electric field of atmosphere
b. changes in moisture content
3. magnetic causes: diurnal, thirteen day, lunar, yearly, and secular variations, etc. (p. 232)
4. artificial causes: presence of rails, pipes, leakage of power circuits, thick bundles of electric wire, buried foundations, excavated archeological sites, neighbourhood of houses, trees.

3. *Biological fields:*

a. *Electric field of man* (p. 173):

α. Main characteristics:
1. polarity between head and feet (p. 180 and 326)
2. symmetrical distribution on left and right side
3. influence fatigue (pot. might disappear), after death permanent disappearance
4. daily fluctuations

β. Static skin potentials: (decreasing if the body approaches a conductor; greatest density of electric charge near strongest curved parts)
1. membrane potentials: up to 100 mV
2. friction potentials (OPPENHEIM effect): several hundred volts (p. 174-177)
3. dust potentials (p. 177)
4. potential gradient of the atmosphere (induced on perfectly insulated bodies)

γ. Dynamic skin potentials (p. 174)
1. direct current potentials:
   a. diffusion potentials: max. 10 mV
   b. membrane potentials: ordinary membranes up to 100 mV monomolecular membranes: up to 900 mV
   c. alteration potentials: up to 20 mV
   d. DONNAN equilibrium potentials: few mV
   e. injury potentials: 20-30 mV
   f. thermo-potentials: few mV
   g. compression potentials: few mV
2. alternating current potentials:
   a. action currents of heart muscles: few mV
   b. diaphragm currents: few mV
   c. brain potentials: 2-1,000 μV
   d. electric potentials in nerve-endings in the skin: less than 300 μV
   e. action currents of skeletal muscles 10-200 μV (HEYDWEILLER-SCHUMANN effect, p. 178)

δ. Skin resistance (p. 183):
1. fluctuating with the place of the body
2. changing with temperature, humidity of the air
3. changing with moisture, salt content, acidity of the skin (perspiration influence, p. 186)
4. daily fluctuation, yearly fluctuation (highest in morning, decreasing after lunch, increasing in evening)
5. changing due to drug application
6. changing due to perspiration (see sub 3)
7. psycho-galvanic reflexes (p. 186)

ε. Causes of changes of electric field of the skin (both in magnitude and sign)
1. changes in capacity of the body (neighbourhood of conductors increase capacity)
2. changes in resistance of the skin
3. changes in factors creating skin potentials
4. photo-chemical and photo-dynamic effects (p. 71)
5. changes in structure of the skin (and its composition)
6. influence of menstrual cycle

b. *Electric field of animals* (p. 197-199): skin potentials less than 100 mV Causes of changes: same as man; also polarity phenomena.
c. *Electric field of plants* (p. 200-202): electric potentials generally $\langle$ 50 mV; varying in magnitude and sign for different parts of plants; polarity phenomena; relation potentials and shape of fruit (p. 15); diurnal variations of trees.

(B) Magnetic stimulation

1. *Mechanism of bio-magnetic effects:*

a. magneto-striction (p. 80)
b. FARADAY effect (on fluid crystals of protoplasm) (p. 30 and 80)
c. Magnetic directive forces (p. 57 and 79): FREUNDLICH- and CARDIN-effect
d. URBASCH effect (influence on ionic movements) (p. 81)
e. Magneto-chemical effect:
   α. magneto-electrolysis (STSCHUKAREFF effect) (p. 82)
   β. magneto-oxidation (PISSARSHEWSKY effect) (p. 82)
f. Nerve induction currents (HERMANN-DANILEWSKY-SCHIFF-GRANDIS effect) (p. 121)

Total effect determined by kind of magnetic field (alternating-, pulsating-, constant), intensity, direction with respect to the body and duration (Law of constancy of excitation energy, Law of TALBOT, p. 83 and 98)

2. *Causes of magnetic gradients in earth magnetic fields:*

a. *Permanent disturbances:*
   α. Continental anomalies:
   β. Regional anomalies:
      1. on land: above folded structures, large igneous massifs, volcanic lava flows
      2. on sea: above submarine folds, fault blocks, submarine extrusions
   γ. Local anomalies:
      1. *Geological causes:*
         a. changes in rock composition (magnetic effect determined by relative magn. susceptibilities of different components, percentage of each mineral and distribution in space; traces of ferro-magn. minerals, ilmenite, pyrrhotite or magnetite, create para-magn. effects; p. 75)
         b. changes in geological structure (folding, faulting, caves)
      2. artificial causes:
         a. metal pipes (water, oil) composed of iron, manganese, nickel or other para-magnetic substances or para-magnetic alloys (p. 76)
         b. reinforced concrete beams or pipes
         c. stoves and other magnetic parts of furniture

b. *Periodical disturbances* (p.275):

α. Daily variations:
1. change in declination 10′; amplitude of hor. int. varies up to 50γ
2. change smallest in morning, greatest at 2 o'clock
3. change less in winter than in summer

β. Thirteen-day period

γ. Lunar period

δ. Yearly variations: max. easterly deviation on N. hemisphere in August
max. westerly deviation on N. hemisphere in February
amplitude of declination $2\frac{1}{4}''$

ε. Secular variation

ζ. Magnetic storms

η. Eleven-year period

c. *Induced magnetism:*

α. vertical iron bars, rock cliffs (p. 84), lava flows (p. 85) with N. pole at base

β. horizontal iron bars with S. pole at S. end, N. pole at N. end (p. 84)

γ. lightning effect: circle of rock magnets (created in debris of basic rocks) alternatingly with S. and N. poles; p. 85)

(C) Electro-magnetic stimulation

1. *Stimulation by natural electro-magnetic sources:*

a. *Sunlight:*

α. General mechanism of electro-magnetic effects:
1. Influence of non-ionizing radiations (ultraviolet):
   a. Photo-chemical action (excitation, p. 71)
   b. HALLWACH effect (p. 64): emission of free electrons The smaller λ, the greater emission. Greater intensity, stronger emission. Influence of polarization of light. Influence of long waves on recovery of photo-electric fatigue
   c. Biological effect if $\lambda > 300$ mμ very small. Influence depending on abs. coeff. of protoplasmatic tissues. A.C. depends on molec. structure of cells, being different for nucleic acid and proteins (p. 66), ratio being different in different periods of the year.
2. Influence of ionizing radiations without appreciable heat transfer (p. 64): (radioactive radiation, cosmic rays, proton rays-RUSSELL effect, p. 45)
   a. indirect action: almost all org. compounds in dilute aqueous solutions are decomposed by irradiation due

to disintegration of H_2O in H and OH radicals, the latter being absorbed during oxid., making org. subst. into good electron receptors (p. 67); particularly effect on enzymes, occurring in low concentrations in cells (p. 66)

b. Direct action on large molecules (p. 67): effect inversely proportional to mol. weight

c. Localizing effects (p. 67): chromosome destruction

3. Radiation accompanied by heat transfer (high frequency Hertzian waves) (p. 65 and 68)

   a. Greatest heat development in tissues with highest conductivity; in fats and other tissues with low conductivity small effect (p. 65)

   b. Permanent internal changes due to electric vibration.

β. Mechanism of ultraviolet stimulation of the skin ($\nu = 1.0 - 390$ m.μ)

1. Changing electric potential of mono-molecular layers and their thickness (p. 72)
2. Oxidation of melanin pigment in epidermis of skin (p. 71)
3. Histamine formation in epidermis cells, which diffuses and acts on blood vessels beneath (erythema, p. 71)
4. Increased androgen secretion, creating sexual stimulation (p. 73)
5. Stimulating the GURWITSCH effect, particularly at certain wave intervals (p. 23):

GURWITSCH effect (if existing) due to:

   a. oxidative processes (particularly metab. proc., p. 24), mitotin in presence of mitotase oxid. in oximitotin
   b. glycolysis in muscles and other tissues (p. 25)
   c. proteolysis, i.e., breaking down of proteins in their soluble decomp. products (p. 25)

   GURWITSCH radiation subject to diurnal rhythm (p. 26): peaks of mitosis at night

γ Mechanism of infrared stimulation of the skin ($\gamma = 770$ mμ — 220 μ):

Smallest perceivable rate of warmth = $15 \cdot 10^{-5}$ gcal/cm²/sec = $63 \cdot 10^2$ erg, this sensation being evoked in 3 sec by exposure of 200 cm² surface of skin, the total exchange of energy being 0.09 gcal (p. 118)

Total change in skin temperature due to this radiation 0.003°C

Local exposure to infrared rays causes (p. 118):

1. Activation of vascular tissues and increase of amount of blood in the skin (heat hyperemia, p. 71)
2. General stimulation of vasomotor mechanism (p. 118)
3. Stimulation of sensory nervous system of the skin

4. Induces sweating (bringing urine products, salt, etc., to the surface of the skin)
5. Increased heart rate (influencing frequency of heart action currents, blood pressure)
6. Increased respiratory action
7. Increased metabolism
   a by influencing the anterior lobe of the pituitary gland which can lower the combustion rate 40% below normal (p. 119), as a result of secretion of thyrotropic hormone into blood; the gland being stimulated by nerve fibres of the hypothalamus (p. 121 and 130)
   b. by stimulating the adrenal medulla; this produces adrenalin, which in high dilution in blood lowers the blood pressure due to vasodilatation in the arterioles of the skeletal muscles, the main source of heat production
8. Increased lymph formation and lymph flow

Different processes being counteracted by heat loss of body:

1. by radiation ($\lambda = 5 - 20\mu$): abt. 55% of lost heat (at 27° C and 25% humidity)
2. by convection: 15% (" ")
3. by evaporation: 25% (" ")

each process influenced by temperature and humidity of surrounding air

Causes of infrared stimulation

1. changing atm. radiation
2. changing terrestrial radiation ($4 - 50\mu$)
3. neighbourhood of hot bodies and living org.

δ. Mechanism of visual light stimulation ($\lambda = 390 - 770$ mμ):

Smallest perceivable light flux $1.7 \cdot 10^9$ erg/sec, able to bleach 5—14 mol. of visual purple (rhodopsin), the transferring agent of chem. energy into electric energy in the rod cells (p. 115), or jodopsin in cone cells, impulse transmitted along eye-nerve, lateral geniculate body (thalamus, p. 131) to optical area in cortex.

Differences in sensibility created by:

1. difference in structure and absorption power of pigment
2. difference in the three types of colour cone-cells (p. 116)
3. difference in ratio between cone- and rod cells (p. 115)
4. difference in visual range (generally between 396 and 712 mμ)
5. emotional states (p. 113)
6. differences in swelling of collagen of cornea (p. 113)
7. differences in protein structure of eye-lens (p. 114)

ε. Causes of variations in electro-magnetic stimulations:

1. fluctuations in the intensity of light received by the skin (p. 69-73):
   a. geographical factor:
      1. influence latitude: U.V. radiation greatest in tropics (if not humid and dusty); smallest at high latitude
      2. influence altitude: U.V. increases with altitude, particularly greatest relative increase in scattered sunlight
   b. geological factor: influence ground cover
      1. snow, water, ice increase reflected U.V. rays, particularly short ones
      2. reflection by snow $= 2 \times$ sand $= 4 \times$ water $= 8 \times$ grass cover
   c. meteorological factor:
      1. influence ozone: strong absorption capactity of U.V. rays; greatest abs. at great height, in spring $>$ autumn, max. ozone (and abs.) at low barometric pressure
      2. influence water vapour (clouds): U.V. *rays*, reflected against lower part of clouds, increases U.V. intens. *Infrared* ($\lambda > 800$ mμ) strongly absorbed; on humid days practically all terrestrial radiation ($\lambda = 4 - 50\mu$) absorbed
      3. influence dust: in streets 20% less ultraviolet than in open fields
   d. cosmic factor:
      1. *ultraviolet:* at midday more U.V. rad. than in fore or afternoon; in summer more than in winter (abt. 1,000% richer at midday); in autumn relatively richest in U.V.; if sun sinks U.V. decreasing
      2. *Infrared:* summer 10% richer in I.R. than in winter, 45% richer in red, 90% richer in green, 250% richer in blue violet; spring relatively richest in infrared; if sun sinks infrared increasing.

2. biological fluctuations:
   a. fluctuations in penetration depth of skin:
      1. *ultraviolet:* waves $<$ 320 mμ penetrate only 0.1 mm (p. 70)
      2. *infrared:* max. penetration with $\lambda = 750$ mμ, few mm (p. 70)

      position of heat bodies at 1.75-2.5 mm below surface of the skin; general feeling 2.0 mm; cold 1.0-1.5 mm; intensive pain 1.0 mm; superficiaal pain 0.25-0.5 mm (p. 129)
   b. biological fluctuations (p. 72):
      1. blondes more sensitive than brunettes
      2. males more sensitive than females
      3. persons between 20-50 years of age more sensitive than younger and older people

4. increasing sensitivity during first 7 months of pregnancy
5. unstable nervous system, over-active thyroid gland, elevated blood pressure, active tuberculosis increases photo-sensitivity
6. seasonal factor: max. sensitivity in March-April and October-November
7. different ratio between nucleic acid and proteins (p. 66) determining difference in abs. coeff. of U.V. rays

c. photo-sensitivity
1. natural photo-sensitivity: local photo-sensitivity or photo-allergic phenomena (p. 73)
2. artificial photo-sensitivity: photo-dynamic action of fluorescent dyes (p. 72) at concentrations of 10^{-7} and less
   α. dyes absorbed as food
   β. absorbed by the skin through external contact, particularly if applied in fatty base; e.g., coal tar prod., meadow plant compounds (furocumarin compounds); perfumes containing oil of bergamot or citron oil; many drug (pH of surrounding fluid being very important); acid hydrolysis of many proteins by enzymes

3. fluctuations due to polarization (p. 69):
   a. scattered light in dusty atmosphere is polarized
   b. light from blue sky: 90° from the sun partically polarized; 160° from the sun and 20° above and below the sun unpolarized
   c. degree of polarization fluctuates with altitude of sun, wavelength of light, degree of turbidity of atmosphere, general weather conditions

b. *Cosmic rays:*

Mechanism of cosmic ray stimulation: see p. 63 and 65
Biological effects: exp. of FIGGE (p. 284)

2. *Stimulation by artificial electro-magnetic sources:*

a. *X-rays:*
b. *High-frequency Hertzian waves* (λ generally $>$ 30 cm, n $<$ 10^8 Hz): in neighbourhood of high-frequency transmitters
   α. Mechanism of Hertzian stimulation: heat transfer (p. 65, 68); electric vibration
   β. Main biological effects (p. 284): stimulation of extremities, fatigue, apathy, headaches, drowsiness

(D) Acoustic stimulation

Mechanism of acoustic stimulation:

a. *Stimulation with acoustic vibrations with* n $\langle$ 20,000: smallest perceivable stimulus = 10^{-13} erg

α. Mechanism of stimulation: acoustic vibrations create bending movements of hairs of hair-cells in the organ of Corti (p. 107), stimulus transmitted to nervus acusticus and auditory area via thalamus (p. 131), in particular the cortical relay nuclei (medial geniculate body, p. 132)

β. Stimulation of motor nerves: stimulated auditory area of cortex relays stimulus to lateroventral nucleus of thalamus (p. 132), stimulating motor area of cortex

b. *Stimulation with acoustic vibration with* n $\rangle$ 20,000 (*supersonic waves*):

$\lambda = 6$ cm — $2 \cdot 10^{-3}$ cm; ν = 1,200 m/sec.

α. Mechanism of stimulation (p. 109):

1. cavitation: formation of gas-bubbles
2. physico-chemical effects: depolymerization, increased oxidation, liquefaction of gels, dispersive action on crystals in fluid (p. 109)
3. thermal effects (p. 109)

β. Biological effects (p. 108): waves focussed on cerebral cortex cause disturbances in motor area of cortex.

(E) Stimulation with volatile components

1. *Mechanism of volatile stimulation:*

a. *Olfactory stimulation:*

α. Mechanism of stimulation: Odorous substances diffuse through olfactory cells in epithelium of nasal cavity (causing delay in perception, p. 101), stimulating olfactory nerve and trigeminal nerve (p. 101) and via posteroventral nucleus (thalamus, p. 132), stimul. sensory cortex. If breath held no olfactory perception (p. 102)

with man: smallest perceivable odorous substance: 10^{-8} mg trichlorphenol = $3 \cdot 10^{10}$ mol., perceivable after sniffing only once (p. 102)

with dogs: piece of rock held 1-2 sec in hands of master can be recognized.

Possibility of sensitizing on specific odours (particular cap. of dogs) due to resonance phenomena (RAMAN effect, p. 102) between smelling substance and olfactory cells (see also relation checking agents and odorous substance, p. 102)

β. Causes of differences in perception:

1. organic causes:
   a. variations in thickness and structure of epithelium of nasal cavity and olfactory cells
   b. variations in conductivity of olfactory and trigeminal nerve
   c. variations in speed of relay in thalamus
   d. variations in size of sensory cortex
2. geological causes:
   a. humidity and porosity of soil (humid soil retains odours, dry sand absorbs badly, p. 104)
   b. vegetation influences absorption
3. meteorological causes: influence wind, rain, irradiation, temperature, barometric pressure, clouds (p. 104)

b. *Stimulation of taste cells:*

α. Mechanism of stimulation:

1. direct chemical excitation of taste buds and cells:
   a. through oral cavity
   b. indirectly by substances injected in blood stream (p. 106)
   transmission of stimulus along 7th, 9th and 10th brain nerve via thalamus (posteroventral nucleus, p. 132) to sensory cortex (gustatory area); stimulus can spread through thalamus to other parts of cerebral cortex
2. stimulation by weak electric currents in the head (p. 106)

β. Kinds of stimulation:

1. sweet taste: by alcohols, aldehydes and ketones (perceivable at tip of tongue)
2. salty taste: by salts (on tip of tongue)
3. sour taste and bitter taste: by alkaloids (posterior part of tongue)

γ. Results of taste stimulation:

1. reflectorical excretion of sputum by the glandulae salivales (p. 106), increasing chemical reaction between stimulating substance and taste cells
2. direct stimulation of taste nerves and excretion of sputum cause reflectorically excretion of gland saps in digesting organs (p. 106)

2. *Causes of volatile stimulation:*

a. *Influence of soil:*

α. Radium emanation: average content of atm. $6 \cdot 10^{-18}\%$ (p. 242)

β. Non-radioactive compounds:

1. *volcanic soil:* H_2O_2 S, H_2S, SO_2, HCl, Cl_2, CO, CO_2, CH_4, H_2, N_2, O, H_3BO_3, Fe_2Cl_6, $AsCl_3$, traces of H_2SO_4, NH_3 (p. 239) Quant. dependent upon temp. of volc. liquids in neighbourhood
2. *non-volcanic soil:*
   a. soil rich in organic sediments (p. 239):
   oil-regions: $C_n H_{2n+2}$, mainly CH_4, but also CO_2, N_2, O_2 H_2S; traces of $C_n H_{2n}$, CO and H_2, Helium
   marshy regions: CH_4, CO_2, NH_3, PH_3, P_2H_4
   b. soil composed of non-organic sediments: odours due to crushed plants (p. 240), flowering plants, burrowed moist soil, soil bacteria, toadstools etc.

γ. Causes of variations in volatile stimulation:

1. meteorological factor:
   a. periodical fluctuations: depending on hour of the day and period of the year
   b. aperiodical fluctuations: due to temp., atm. pressure, precipitation (rain, snow, ice), irradiation, clouds, wind
2. geological causes:
   a. soil structure: porosity, permeability, faulting, etc.
   b. topography
   c. humidity of soil

b. *Influence of atmosphere:*

α. Influence of gases (p. 259)

1. ozone: smallest perceivable amount at conc. of 10^{-6}; influences respiratory metabolism unfavourably due to lack of cap. to be absorbed by blood
2. nitrogen oxides: NO, NO_2, HNO_2: 0.5-1 mg/L air for ½ hour causes death

β. Influence of dust (p. 177)

absorption of mineral fragments with electr. charges opposite the skin charges (charges of mucous membranes of nose and mouth), influence on monomolecular membranes (p. 18); absorption of ferro-magnetic dust particles by non-living matter may create para-magnetic effects.

c. RUSSELL-STEMPELL *effect:* all living and non-living matter surrounded by volatile aura (p. 48); phantom phenomena on photographic plates (p. 36)

α. Mechanism of RUSSELL effect: influence on colloids

1. cause of volatile stimulation:
   a. release of adsorbed H_2 and organic compounds, particularly terpenes

Produced in rooms: by burning of gas (H_2, CO, methane, ethylene; p. 45), etc.
In open air: by escaping soil gases

b. production of H_2 by metals: determined by electromotive series (p. 44)
produced by:
1. contact with steam
2. contact with dilute acids (p.46): HCl, H_2SO_4, CO_2, $NH_3 + H_2O$
3. contact of Zn or Fe with inactive metals such as Cu or Pt creating electric couples and hydrogen (p. 57)
4. NaCl of skin with electric currents in skin

c. increased release due to presence of strongly absorbing substances in neighbourhood (colloidal substances)

2. physico-chemical processes during stimulation:

Influence of reducing agents:
a. H_2
b. terpenes and the main component pinene ($C_{10}H_{16}$), being easily oxidized in moist air, sunlight etc. (p. 47)

Reduction and oxidation accompanied by alteration potentials (p. 18), reduced substance becoming electrically negative
Process influenced by diffusion speed: $H_2 = 1840$ m/sec.
Diffusion in straight lines (p. 46), effusion rate inversely proportional to square root of density of gas

3. bodies causing Russell effect:

a. inorganic substances (metals): Mg (strong), Cd, Zn, Ni, Al, pewter (75% Sn, 25% Sb), Bi, Sn, Co, Sb, Hg (very weak) (p. 36). Inorg. compounds mostly inactive, also H_2O
b. organic substances: vegetable oils
essential oils (p. 36)
c. living matter: wood very active, particularly wood of conifer (in ½ hour effect on photogr. plate);
oak, beech, acacia are active; ash, elm, plane slightly active (p. 38); even very old wood active; activity varies for year-rings and moisture content (increased moisture increases act.);
also straw, bamboo and hay are active (p. 39)

4. causes of fluctuations in Russell effect:

a. difference in transparency of intermediate substances: glass, selenite, mica, are opaque; gelatin, celluloid, paper transparent (p. 39)
b. influence of temperature: heating of body increases effect (p. 40)

c. influence of wavelength: radiation increases activity of wood (white light); metals not activated in sunlight; activation only due to blue light, red and green inactive; activation remains 14-30 days after irradiation; wood only increasingly active after irradiation if it contains resin or allied substances (p. 41)
d. influence of air currents (p. 34)
e. inducing effects (contact with or proximity of organic substances) (p. 34)
creating "shadow phenomenon": by impregnation with volatile comp. (reducing agents)
by impregnation with ferro-magnetic dust (p. 177)

β. Mechanism of STEMPELL effect: influence on rhythmic preciptitaions (p. 48-53)
1. oxidational processes check precipitation, reductional processes increase the formation of rings
2. slight emanation of gas increases the precipitation, intensive emanation checks it.
3. intensive irradiation increases the formation of rings, darkness decreases it.
4. very small and very large λ rather inactive;
average λ, particularly near ultraviolet, influences STEMPELL-effect
5. cause of oxidational effect in case of onions: allylsulphide
in case of garlic: allyldisulphide.

Of these different forces only the electro-magnetic, acoustic and volatile stimulations seem to be large enough to create a direct excitation of nerve endings in the arm which could stimulate the motor nerves of the arm muscles.

The experiments with electric fields, discussed on p. 318, with artificial magnetic fields (tangent-galvanometer) (see p. 320)and with volatile stimulation, indicate that rather long latent periods exist between the moment excitation begins and when the first observable excitation phenomena appear. This suggests that the electric stimulus in the nerves (either by conducting of electric charges through the skin or membranes, or by direct induction in the nerves or by transformation of chemical energy into electrical one, etc.) is not directly conducted to the motor nerves of the arm muscles but through the relay station of the thalamus to the different sensorial areas of the cortex. The excitation spreads to the motor area (see p. 132 and 196) and after being amplified in the brains, passes back along the motor nerves to the muscles of the arm and hand (see p. 196). We have seen on p. 194 that three nerves are of primary importance: the *musculospiral*, the *ulnar* and the *median nerves*.

We have seen that the smallest skin resistances occur in the centre of the palm and that maximal responses on external stimulation

are obtained from the areas near the thumb and adjacent surfaces of the palm and index finger. It therefore seems logical to assume that in the case of electric stimulation with a conducting metal rod, those people are sensitive to dowsing whose skin resistance (direct current —) is far below 20,000 ohm. On the other hand dowsing occurs with all kinds of non-conducting rods. We have mentioned the experiments with a string-galvanometer, without using a rod; these indicate certain changes of the skin potentials of a dowser if he passes strong dowsing zones, which are the same as in the experiments with a divining rod. In other words the divining rod is not essential; it serves only as an indicator of changing muscular contraction, i.e., a change in number of discharging motor units of the motor nerves.

This change in skin-potential might have two causes:

1. Changes in the action currents of the nerves and the different physiological processes that regulate the skin-potentials, creating indirectly a change in skin potential.
2. Direct changes of the skin-potentials as a result of change in capacity of the human body. If the human body, with an active E.M. force, moves through a dowsing zone it can be compared with an electrically charged body with insulated supports (rubber soles) moving through electric, magnetic or electro-magnetic fields. If the source of disturbance in the dowsing zone is a conductor, the capacity of the insulated body will increase if it approaches this conductor, i.e., the potential decreases (see Appendix I, p. 433). The faster the movements the greater the capacitive changes and changes in potential. This effect can be demonstrated by connecting an electrostatically charged metal plate with an electrometer; on bringing the hands near to the plate the potential of the electrometer decreases (i.e., the capacity increases).

The process of turning of the rod will be different above non-living objects and above living organisms. Although many of the detail problems still await further experimental work before a final explanation can be given, the main processes can be summarized as follows:

1. *Cause of turning of the rod above non-living objects*

Movement of a dowser creates the following phenomena:

a. *Change in skin-potentials*, if the dowser approaches a conductor or if he approaches an earthed object (walls of a room, etc.), stimulating the nerve endings in the skin.

   This change is influenced by the following factors:
   1. the skin resistance (if very high, no stimulation occurs)
   2. the degree of insulation of the shoes
   3. the conductivity of the soil (depending on potential gradient, composition of soil, water content, earth-currents, etc., and factors influencing each of these magnitudes)

4. the speed of movement
5. the conductivity of the atmosphere (depending on potential gradient, temperature, humidity, atmospheric pressure, etc.)

b. *Change in kind and number of absorbed aero-ions* that stimulate the nerve endings of the skin and the blood capillaries of the lungs. These ionic changes are influenced by atmospheric conditions, such as potential gradient (depending also on the conductivity of the soil), presence of metal conductors, etc. (see also p. 330 and 334, relation between dowsing zones and ionization).

c. *Changes in the magnetic field of the earth*, created by presence of ferro or paramagnetic substances (pipes, beams, etc.) or pronounced diamagnetic bodies, causing magnetic gradients which induce very weak currents in the nerves near the surface of the skin (probably influenced by diurnal variations, etc.)

d. *Change in potential difference between arm and earthed objects (or electrically charged bodies)*. The potential of the arm depends on biological causes (see p. 173) and on the atmospheric potential gradient at the level of the arm. Change in curvature of equipotential lines in the atmosphere and in distance between the arm and earthed objects cause electrostatic stimulation.

e. *Change in electromagnetic radiation as a whole* or *changes in irradiation intensity of different parts of the body:*
   1. Irradiation by infrared rays:
      α. in neighbourhood of houses, stone walls, etc.; heating mostly differential (i.e., part of the human body nearest to the wall is strongest irradiated)
      β. in open air by rays of the sun as direct irradiation or indirect terrestrial irradiation
   2. Irradiation by ultraviolet rays: rays of the sun
   3. Irradiation with high frequency hertzian waves: in the neighbourhood of radio transmitters

   Influence of first two radiations changes with ground cover (vegetation, rock composition, difference land and water or snow resp.), atmospheric conditions (clouds, dust, etc.), diurnal variations in sun radition, photodynamic sensitivity of the skin, polarization of suns' rays, etc.

f. *Change in volatile stimulating agents*, influence varying due to meteorological and geological causes.

The influence of acoustic stimulation is probably an exceptional case and of no practical importance for dowsing in the field. Turning due to hypnosis (see p. 387) and auto-suggestion have also been omitted in this discussion.

It is not always easy to differentiate between each of the above mentioned processes during dowsing experiments. Some people react on all 6 factors, but several dowsers have a specific sensitivity for only one.

Although our studies on the methods, for differentiating clearly between each of these processes, have not yet been completed, a few general remarks on these methods can be made:

1. If a dowser obtains a dowsing reaction and he repeats the experiment holding his breath, and this time no reaction is obtained with the rod (assuming the dowser is not sensitive to suggestion otherwise the rod turns again) it is a good indication that either aero-ionic or (and) volatile stimulation is the cause of the dowsing reaction.
2. Dowsing zones in houses which cannot be confirmed with a compass are not due generally to magnetic gradients.
3. If a dowser notices a change in dowsing reaction, when walking at different levels above the soil and the reaction increases with increasing elevation, the effect is usually due to the potential gradient of the atmosphere.

Many of the detail phenomena of dowsing have been omitted in this discussion as they can be explained by considering the *laws of electric stimulation of nerves* (see p. 135-138) and *muscles* (see p. 165-169). For each case a different combination of these laws has to be applied and as they are themselves rather complicated it is evident that the detail explanation of each dowsing reaction is most difficult and requires a careful physical and physiological analysis of all the factors influencing the process.

2. *Cause of turning of the rod above living organisms*

On page 303 we described the different reactions of a dowser walking with a rod along a person lying on a settee or bed. On page 197-202 we discussed the electric field which surrounds both animals and plants; also man is surrounded by such an electric aura (see p. 326-327). The polarity phenomena observed by dowsers have been confirmed with animals and plants by the electric studies of BURR a.o.; our own experiments with a string galvanometer have shown polarity phenomena on the human body, which seem to be different for males and females (see p. 326). TROTSENBURG a.o. (see p. 180) also observed these electric polarity phenomena on man.

As SCHUMANN, SAUERBRUCH, HEYDWEILLER and ARDENNE (see p. 178 and 179) could register these electric fields even at a great distance, by using extremely sensitive physical instruments, it would be strange if the human body, being one of the most sensitive physical instruments imaginable could not do the same. Our experiments with the string galvanometer confirm this assumption. The deeper mechanism of registration of the electric field of living organisms by the human body is not yet known in all its details but a few general statements can be made.

The fact that the human field can be registered after the person has risen from the settee or bed indicates that it is not a local disturbance of the magnetic field of the earth which is responsible for the dowsing

phenomenon, as might have been expected after the experiment with artificial magnetic fields (which were disturbed by the presence of human bodies in the bundle of the lines of force [see p. 319, point 2]).

It is most likely that the potential difference between the dowser's arm and the trial person is responsible for the nerve stimulation which is reflected afterwards in changed skin potentials (see above p. 356, sub d).

It is unlikely that volatile stimulation is responsible for it as the phenomenon occurs whether or not the dowser holds his breath. Also, the "shadow phenomenon" which disappears if the bed is earthed suggests that it is a purely electric stimulation. Infrared stimulation is possible too, but although it might increase the electric effect if the body of a trial person is lying on the settee, it cannot be responsible for the shadow phenomenon.

The cause of the polarity phenomenon, although not known in detail, seems logical considering the general biological structure of the living organism which is a result of a polarity of the fertilized egg cell (see p. 126, laws of symmetry). We have seen that this polarity phenomenon in the living cell is due to the crystalline structure of the micellae and chromosomes which is determined by the laws of symmetry of the crystalline inorganic world. It is also the result of one-sided attachment of the oögonia to the neighbouring feeding cells, causing one-side food currents, etc. (see Bibl. No. 1448, p. 164 and 177)

It is more difficult to explain the difference in polarity in males and females. We have seen, however, that many of the physiological processes that cause the skin potentials are different for males and females, and in the case of females different in periods of menstruation. We have seen on p. 118 that the skin is drenched with excretion products of the urine. We can therefore expect different sexual hormones, etc., in the skin of males and females. As the general composition of the skin influences the skin potentials it would be possible for this difference between male and female skin to be responsible for the difference in polarity.

As the growth of the embryo is considerably influenced by the presence of certain hormones which seem to be different for male and female embryos (see p. 396) it might be that this difference in polarity originates during the first stages of sexual differentiation of the embryo.

The difference between primary and secondary sexual organs of males and females might also create this difference in polarity. Although a considerable amount of research is required to explain this, there is little doubt that the difference is real and it is logical that the registration of the electric field of man should be different above males and females.

We did not mention now *the cause of different direction of turning of the rod*. It is evident that direct or indirect stimulation either with electric, magnetic or electro-magnetic forces will be strongest at the side of the body nearest to the source of disturbance. This theoretical expectation is confirmed by the experiments described in previous pages.

3. *Explanation of the "shadow" phenomenon*

On p. 303 we described the "shadow phenomenon" that takes place when a person rises from a chair, settee or bed. With an electrocardiogram experiment (such as described on p. 326) it can also be shown that after the person rises from the table the diagram remains restless and only if the table is earthed and the surface is rubbed with a wet towel does the effect disappear. We have seen that also if the bed is thoroughly earthed the Shadow phenomenon disappears. All these observations suggest that the shadow phenomenon is purely electric and can be explained as follows:

A person lying on a mattress (on top of a metal frame) can be compared with an electrical condenser composed of two conductors (human body and metal frame) and an insulator in between (mattress) with a resistance of more than 10^7 ohms. The upper conductor is charged, the lower one is earthed. By lifting the upper conductor (person rises) the condenser discharges, but similar to the ordinary curve of discharge of condensers the discharge takes place first rapidly and slows up gradually. A residual charge will remain for a considerable length of time. As most objects are not completely earthed a permanent electric field will remain in those objects.

The problems of psychometrics (see p. 395) and phantom-phenomena might be due, at least partly, to this condenser effect in objects and rooms. A person with a strong electrical aura living for years in a room might create certain condenser effects in the surrounding objects which are registered by super-sensitive diviners. An ordinary dowser is capable of discerning whether a bed, chair or settee has been used or not and whether a male or female person was sitting on it. An extremely sensitive person might be able to discriminate between other characteristics of the electric field of man which are typical for certain living conditions of that person in the past.

D. Causes of error during dowsing experiments

The previous discussions have shown that an ordinary dowsing reaction can be disturbed by a great number of factors, some of which are controllable, though the majority are not. The following table gives a brief summary of the main disturbing factors during dowsing. It does not pretend to be a complete list of all disturbing factors.

I. *Varying contact between rod and palm:* due to varying conductivity of the skin of the palm (created by variations in temperature of the body, salt and moisture content of the skin, etc.)

II. *Varying amount of electric charge lost from the body:*
   - A. Through our feet:
     - a. influence of friction electricity created by our shoes and clothes;

b. varying insulation (varying humidity) of the soles of the shoes;
c. varying potential of the surface of the earth:
1. atmospheric influences (changing potential gradient due to rain, clouds, etc.),
2. periodical changes (due to atmospheric and cosmic causes) in the electric potentials of the surface of the earth (created by earth-currents)
3. changes in the ground water level,
4. leakages of electric tension lines;
d. varying humidity of the soil.

B. Through the remaining parts of the body:

a. varying conductivity of the skin;
b. varying conductivity of the atmosphere;
c. varying skin potentials.

III. *Varying capacitive changes:* Due to difference in speed of the moving dowser.
IV. *Periodical variations of the earth-magnetic field*
V. *Varying sunradiation*:
A. Periodical variations:
B. Non-periodical variations: clouds, vegetation, etc.
VI. *Varying concentration of volatile, stimulating compounds*
VII. *Vegetation:* trees and their roots are particularly likely to create disturbances that prevent accurate measurements.
VIII. *Influence of the direction of movement of the body with respect to the zone of disturbance:* this should be known together with the direction of turning of the rod.
IX. *Presence of living organisms near the divining rod:* every human body creates observable deviations in a divining rod if he approaches the rod within 50 cm (sometimes even more).
X. *"Slow reaction speed" and fatigue phenomena in the arm muscles.*
XI. *Varying conductivity of the nerves:* alcoholic drinks, metabolic processes, fatigue, etc., change the conductivity of nerves.
XII. *Varying sensitivity of the reception centre* (central nervous system and brains): due to fatigue, lack of concentration during the experiments, other psychic influences.

E. Summary of precautions to be taken during dowsing experiments

As with a normal geophysical survey it is necessary to follow some *general rules* during each dowsing survey.

1. The dowser should return regularly to a few base-stations in order to be certain that changes in atmospheric conditions, etc., are not interfering with his observations. If the turning of the rod differs considerably after the dowser returns to a base point and this is not

due to fatigue (which an experienced dowser can feel very easily) corrections have to be applied.

2. A divining rod must be used with such a device that accurate objective readings of the rate of turning of the rod can be obtained.
3. During each experiment the dowser must start to follow certain profile lines, without deviating to the left and right. The direction of his movement and the direction and rate of turning of the rod must be continuously recorded on the map.
4. The results must be plotted on the map before any interpretation is given.
5. A general geological survey of the surface soil (composition, moisture content and structure), tectonical features (folding, faulting, etc.), topography, distribution of land and water and the vegetation should be made and indicated on the map.
6. The temperature, humidity, atmospheric pressure, kind of cloudedness and light intensity (with a photo-electric cell) should be registered continuously by a second person who follows the dowser at a distance of a few metres.
7. After the profile-survey is completed and *equi-rhabdomantic lines* (i.e., lines connecting points with same dowsing effect) have been plotted, the lines must be checked by following the curved lines. Differences with the map must be corrected.
8. The survey should be repeated if possible at different successive days and the interpreted maps should roughly coincide. During the survey the dowser should not consult the map prepared the previous day. Maps are prepared by the topographer who is doing the surveying.
9. It will be necessary if possible, to start from a known source of disturbance (a surface fault, water well) in order to be certain what a certain turning of the rod in that particular area could mean.
10. One should establish as far as possible whether the different dowsing reactions are due to volatile stimulation (dowser could repeat the experiment by holding his breath or by using a gas mask), magnetic effects, etc.

In addition to these general rules several *precautions* have to be taken *to eliminate* as far as possible *the ordinary sources of error* discussed above. The main precautions are:

1. The grips of the rod, particularly if a metal conductor is used, should be kept in cloth saturated with a salt solution in order to obtain a minimum and constant resistance of the palm. The cloth must be wetted regularly. Even with non-conducting rods it is preferable to lower the skin resistance as much as possible.
2. The dowser should travel in a car with large glass windows and rubber tyres:
   a. this excludes influence of insulation and friction-electricity of shoes;
   b. atmospheric influence of wind and temperature are less;

c. the speed of movement is large and constant;
d. a certain strip can be measured in two directions in a few minutes and one is able to come back to the base point after short intervals.

3. No persons should be within 50 cm from the divining rod.
4. No measurements should be made in the neighbourhood of trees.
5. In order to minimize the influence of atmospheric conditions, measurements should preferably be made in dry weather, if possible in non-cloudy weather.
6. The influence of varying conductivity of nerves could be reduced by taking the following precautions: measurements should be made in the morning after a good night's rest, not immediately after breakfast; alcoholic drinks should not be taken before or during the measurements.
7. During the observations the dowser should concentrate on the work and not speak unless absolutely necessary (this is necessary for any accurate sensorial observation).

By taking all these precautionary measures it is possible to prepare in a relatively short time a map with equi-rhabdomantic lines, the interpretation of which is a problem similar to the interpretation of any geophysical map and should be done only in close cooperation with an experienced geologist.

F. Influence of dowsing zones on the health of man

At different places in this publication we have mentioned the possible influence of certain external fields on the health of organisms living for a considerable period in those fields. We have seen in the previous pages that dowsing is a reality and not only due to suggestion. Dowsing zones, if they are established with all the precautions indicated above, reflect the presence of certain disturbing external fields. It seems therefore, without any doubt that each correctly determined dowsing zone has a certain influence on organisms living for any length of time in those zones. Whether this influence is favourable or not depends on a great number of external factors but also on the trial person himself. A certain stimulation might be favourable for one organism but might be just above the optimum value of another person and might influence his health unfavourably. Certain fields may have also so little effect that they can be neglected.

The phenomena which have been reported by dowsers, of which a few examples are given on p. 304-305, are sufficiently interesting to recommend on intensive study of this problem. It is too early yet to give an explanation of the medical phenomena reported by dowsers, even if we accepted their observations as facts. It might be useful however to summarize the phenomena discussed in this publication, which might give a clue to the solution of medical dowsing pheno-

mena. The influence of dowsing zones can perhaps be explained by one of the following phenomena:

1. *Influence of induction currents:*

   Dowsing zones influence, directly or indirectly, the skin-potentials and the general electric field of man. This effect, if strong enough, can influence the health conditions in different ways.

   A. *Influence on pathogenous bacteria:*

   α. *Influence of* DE KRUIF-NORTHROP *effect* (see p. 55): If the potential difference between the surface of the bacteria and the surrounding fluid is less than 15 m.V. they agglutinate.

   β. *Influence of electric condition of mono-molecular membranes* (see p. 18): This influences the permeability of the membranes. On p. 118 we explained the excretion of different poisonous substances through the human skin, a process which can be altered as a result of changing electric conditions of the skin. It seems evident that such a process can prove harmful to the general health of a person if he is subjected to such a change in skin potentials for several years in succession.

   B. *Influence on oxyhemoglobin* (see p. 61 and 78):

   Very weak currents cause a subsidence of red colouring matter, development of gas and after long application deposition of colouring matter near anode (GAMGEE *effect*).

   C. *Influence on colloidal condition of protoplasm and blood.* The DE KRUIF-NORTHROP effect should also influence the colloidal suspensions in the human body.

2. *Different bio-magnetic effects:*

   On p. 79 and 264 a summary is given of these bio-magnetic effects. Strong magnetic fields seem to influence the tissues, the chromosomes, the settling speed of erythrocytes, growth, oxygen absorption, cancer, general nervous conditions etc. The Law of TALBOT and the Law of constancy of excitation energy (see p. 98 and 99) indicate similar effects with weak magnetic fields if applied for long periods. Our own preliminary experiments (see p. 275-278) support this assumption.

3. *Influence of potential gradient*

   If the human body is subject to continuous high potential gradients the following effects can be expected:

   A. Direct electrostatic induction in the nerve endings of the skin (GENGERELLI-HOLTER *effect*, see p. 122)

B. Aero-ionic effects: influences respiration, blood pressure, sensitivity of nerves, hemoglobine content, settling speed of erythrocytes, etc. (see p. 261-263).

In this connection the cancer experiments of FIGGE (p. 284) and of VLÈS and DE COULON (p. 255) are interesting and deserve further research.

4. *Influence of volatile matter:*

Traces of soil gases in rooms might be harmful although a normal person will probably not be able to notice them. Several cases of successful experiments where dowsers suggested that the patients move their beds to another room or another corner, might be due to sensitivity of the patient to traces of methane, etc., which escape from the soil (this seems to be true particularly in farm houses in the N. part of Holland).

5. *Influence of soil:*

Dowsing zones often coincide with parts of the soil that differ considerably in conductivity with neighbouring areas.

The electric potential of the soil and the conductivity could influence organic life in different ways. It influences:

a. the potential gradient
b. indirectly the ionization of the atmosphere (particularly the electrode effect, see p. 252).
c. the electric discharge of the human body and therefore the skin-potentials.

This brings us to the end of the section on Rhabdomancy. The following section deals with the pendulum phenomena, known as *radiesthesia sensu stricto* or *pallomancy*. Most of the observations previously made apply also to pallomantic phenomena; discussion of part II can therefore be brief.

PART II: RADIESTHESIA S. STR. (PALLOMANCY)

1. Definition and historical review

Radiesthesia means the sensitivity to radiations, the former being measured by the movements of a pendulum. The existence of biological "*radiations*" (except infrared) are highly improbable, as we have seen in previous chapters. This term should therefore be replaced by the word electric, magnetic or electro-magnetic "*fields*" and it seems preferable to abandon the word radiesthesia and replace it by the more neutral *pallomancy* (see p. 288 and 293). The introduction of the pendulum on a larger scale seems to have taken place only in the beginning of the 19th century.

This *magic pendulum* consisted of a finger ring or piece of metal and was mainly used for locating well sites, etc. It was gradually applied to the study of the radiations of the human body only and was mainly developed by Catholic priests in France as a means of medical diagnosis. It was only in 1930 that the word radiesthesia was created by the abbot BOULY. In about 1935 several engineers and doctors in different countries became interested in radiesthesia. In 1936 war departments in Germany and Italy considered the possibility of using radiesthesists in wartime for finding water. During the second world war they were used particularly in the N. Africa campaign.

In England, the "*Medical Society for the Study of Radiesthesia*" was founded in 1939, and published a Journal "*Radiesthesia*" under its first president, DE GUYON RICHARDS. At present the membership is confined to medical practitioners.

In France the *Société des Amis de la Radiesthésie* was founded under their honorary president, the physicist EDWARD BRANLY; in Belgium the "*Académie des Sciences Radiesthésiques de Belgique.*"

After the war these societies were extended on a more international basis as "*Centre International d'Etude Scientifique de la Radiesthésie*", with headquarters at Bruxelles (Avenue de Tervueren 322), which publishes at regular intervals the *Revue Internationale de Radiesthésie* under its president, GEORGES DISCRY.

Radiesthesia is divided by this society into two branches:

1. *Teleradiesthesia* or *intuitive radiesthesia* or *psychical radiesthesia*
2. *Physical radiesthesia.*

To the first group belong those radiesthesists who use a pendulum above a map or photograph and claim they can indicate certain diseases, ore deposits, etc., hundreds of miles away, at a locality indicated by those maps. However these phenomena, if any truth is in them, do not belong to radiesthesia sensu stricto but to clear sightedness, the pendulum being used only to bring the person in trance (see later part III, causes of hypnotic trance).

Physical radiesthesia explains pendulum phenomena mainly with physical radiations, one of the first leading scientific research workers in this branch of radiesthesia being the civil engineer PAUL SERRES (see Bibl. No. 1277).

2. Types of instruments used

Different types of pendulums have been used, conductors and non-conductors. The first type consists usually of a metal globe often with a short point at the base; a metal chain is connected to the upper part of the globe. The non-conducting type is made of different material, whale bone or ivory being the most favoured. As in dowsing, where the material of the rod proves to be of no importance, the composition of the pendulum is also immaterial, even less so than the rod (the

metal rod giving mostly better results with people not very sensitive to dowsing). The upper part of the chain or wire connecting the globe is usually held with the fingers of the right hand of the outstretched right arm, the pendulum movement being created either by the left hand or by a movement of the right arm. When the pendulum is swinging to and fro it is possible to regulate the strain of the arm muscles to such an extent that the pendulum movement takes place in one plane perpendicular to the body (more or less parallel to the right arm). Unless a disturbing field is present around the body the pendulum remains in this same plane. However, as soon as the same is tried in a dowsing zone or above living bodies, etc., deviations of the plane occur up to 90° and more, which might even change into elleptical rotations of the pendulum and finally into circular ones.

Different instruments have been devised to replace this biologic pendulum by artificial instruments. Examples are the *gerameter*, *magnetic balance*, *neurotonometer* (measuring the potentials drop above diseased organs), *radiosyntonisator*, etc. About these instruments the same can be said as about the artificial dowsing instruments. Before we know the physiological causes of pallomancy it is ridiculous to construct an instrument in the hope that it will replace the human body. Many constructions were made by obviously non-physically trained people or by physically trained engineers with little knowledge of modern geophysical instruments. As a result all instruments produced so far are worthless or poor imitations of existing physical and geophysical instruments. Before any further time is spent on the construction of the "artificial radiesthesist" it is necessary:

1. To establish the reality of the pendulum phenomenon.
2. To study the deeper physiological causes of this process.

3. Summary of observations of diviners

It would require several hundred pages to review all observations reported by radiesthesists. So only a very brief summary is given, which indicates only the general type of observations made by diviners who used a pendulum for their divining experiments.

A. Observations above non-living objects

Two kinds of observations have been made: above non-living natural objects and above artificial objects.

3. A. 1. Natural objects

All places in nature that cause a turning of the divining rod create a deviation of the pendulum from the plane perpendicular to the body. If the diviner stands in the dowsing zone the deviations (or rotations) will be different according to the position of the arm, holding the pen-

dulum, in relation to the axis of the dowsing zone. The rate of deviation consists only of a turning of the vertical plane of oscillation over a certain angle (the pendulum itself swinging to and fro in one plane) or the linear movement changes gradually to elliptical or finally to circular. Generally the stronger the dowsing zone, the more the circular movement will be approached. It might happen therefore that if the right arm is perpendicular to the axis of the dowsing zone and a deviation of the oscillation plane occurs, e.g., of 25°, by turning the body 90° (the right arm parallel to the axis of the dowsing zone) a rotation of the pendulum will be observed. If the arm is perpendicular to the zone and a deviation to the right occurs, by turning the body 180° a turning to the left will be seen. In other words the direction of deviation, as in dowsing, depends on the position of the source of disturbance in relation to the body.

3. A. 2. Artificial objects

Diviners claim that all artificial objects are characterized by a certain aura (they call them radiations) which creates a specific deviation of the pendulum swinging above or near the object. They claim to distinguish between different metals, between paintings of different painters (particularly if they differ considerably in historical period), between different drugs, etc. Deviations also occur above different coloured papers. Their observations particularly in connection with drugs are remarkable if proved correct. They claim, for example, that by holding a certain drug in the left hand, the right hand pendulum deviates only above one of the many drug tablets placed on a table which is the same as the one they are holding in their left hand. This phenomenon of *specific autosensitization* plays an important role in pallomancy and would be extremely interesting if the authenticity could be established beyond any doubt. It is interesting that during all these experiments the rate of deviation increases and the time required for a pendulum to reach the new plane of equilibrium decreases with the increased height of the swinging pendulum above the floor. This *altitude effect* might give a clue to at least one of the causes of pallomantic phenomena.

B. Observations above living organisms

3. B. 1. Observations above plants

The pendulum oscillations obove plants seem to deviate, the rate and direction of deviation being different for different plants. If the left hand touches different parts of the stalk or the leaves of plants, different deviations will occur which indicate a polarity in the biological structure of plants.

3. B. 2. Observation above animals

Deviations of a pendulum oscillating in the right hand occur above animals, without touching them or if so only with the left hand. Animals seem to show a similar polarity phenomenon; this was observed with the divining rod, the polarity being different for males and females. In the case of small animals, e.g., mice, kept in a narrow basin, the pendulum starts to rotate clockwise above females, anticlockwise above males. After the animal is taken out of the basin for some time the same "*shadow-phenomenon*" remains.

3. B. 3. Observations above man

a. With a pendulum oscillating above a person lying on a settee or bed (the diviner standing with his right arm stretched perpendicularly to the axis of the body), the pendulum usually rotates, the direction of rotation being different for the lower and upper part of the body and different for males and females. With males the pendulum usually rotates anticlockwise above the lower part of the body, above females clockwise.

b. If the person rises from the bed a "*shadow phenomenon*" occurs similar to that described under the section Rhabdomancy on p. 303. If a person has risen from a chair, the pendulum usually shows rotational movements (with certain diviners only a deviation of the plane of oscillation), clockwise with females and anticlockwise with males.

c. If different places of the body of a person are touched with the left hand, it is found that each part of the body gives its specific deviation to the pendulum which is oscillating in the right hand; the direction of deviation is symmetrical for the upper and lower part of the body and for the left and right side; clothes create a weaker deviation than direct contact with the skin; the rate of deviations vary for different hours of the day and with the degree of fatigue of the diviner. However, the ratios between the deviations caused by different parts of the body do not seem to change fundamentally if the measurements are made quickly enough; certain parts of the body, if touched, accelerate the oscillations, others retard it; increased muscular activity of a part of the body increases the deviations of the pendulum if this particular part is touched with the hand.

C. Medical observations

We mentioned on p. 367 the *specific auto-sensitization phenomena* with drugs.

Pendulums swinging above urine of man usually rotate anti-clockwise, above females clockwise; no deviations occur if the breath is held.

These experiments and other medical observations of radiesthesists seem to correspond to the results obtained during dowsing experiments (see p. 306-307). We have mentioned that the lower and upper parts of a female body give opposite reactions. A neutral zone occurs between both fields near the umbilicus, above the womb. It has been found by diviners that a rotation of the pendulum occurs during pregnancy above this neutral zone which is different in the case of male and female embryos (see also p. 397.) These few examples indicate the importance of pallomancy if the basic phenomena could be established beyond any doubt.

4. Summary of theories explaining pendulum phenomena

Contrary to water divining, the pallomantic phenomena have been explained by two main theories:

A. The tele-radiesthesists explain the deviations of the rod mostly with uncontrollable supernatural forces that influence the psyche of the diviner and its muscles.

B. The physical radiesthesists generally do not deny the possible influence of electric and magnetic fields but are usually inclined to explain the phenomena with specific radiations emanated by the different bodies, both living and non-living. Scientific evidence for these different radiations, however, have never been advanced.

5. New synthesis of the causes of pendulum phenomena

A. Experiments of Tromp

The experiments carried out by the author on pendulum phenomena can be divided into two groups: experiments to prove the reality of pallomancy and experiments to clarify the physiological processes responsible for the pendulum phenomena.

1. *Experiments that indicate the reality of pallomancy*

Two kinds of experiments were carried out to establish the reality of pallomancy: experiments with artificial magnetic fields created by a tangent-galvanometer (see p. 312) and experiments with electric charges.

Experiments with artificial magnetic fields:

An ivory pendulum, held in front of the tangent galvanometer with the right hand, and swinging to and fro in a plane perpendicular to the body and to the axis of the tangent galvanometer, deviates if the galvanometer creates a magnetic field. This occurs with people possessing great or small skin resistance. The deviation is a function of the field-strength. The sensitivity of the trial person increases with increased tension of the arm muscles and with increasing insulation of the soles of the shoes.

The direction of deviation is always towards the ring of the tangent-galvanometer. If the experiment is repeated with the right arm parallel to the axis of the ring (body turned 90° in relation to the previous experiment) the pendulum starts rotating.

These results were particularly interesting for two reasons:

1. Contrary to the divining rod, people normally non-sensitive to dowsing, with (direct-current) skin resistances of 500,000 ohm and more, were often sensitive to the pendulum movements and could be stimulated sufficiently with a magnetic field; this caused a deviation of the pendulum (the trial person did not know during these experiments when the current was switched on or off). This indicates that a direct magnetic induction effect occurs, probably in the nerve endings of the skin, as only in that case is the skin resistance of no importance. During the previously (see p. 319) discussed experiments with divining rods the stimulus was apparently not sufficiently large to excite the motor nerves of the arm muscle to such an extent that turning of the rod occurs. The mechanism of an oscillating pendulum seems to be considerably more sensitive (see later).
2. Contrary to the divining rod, changes in field strength could be registered with the pendulum; e.g the current is first 1 A and the deviation is registered (e.g., 10°), the current is switched off and the trial person moves backwards. If the current is then increased to 2 A and the trial person moves forward again in the bundle of the lines of force, a much greater deviation will be observed, e.g., 20°. We have seen that with a divining rod the same rate of turning occurs in both cases.

This experiment also suggests a greater sensitivity of the arm muscles with pendulum experiments.

The reality of pallomancy could thus be established in two ways. The trial person should determine whether the current is on or off and he should determine the magnitude of the current. The first experiment succeeded even after a great number of continuous tests (more than 10). The second test could not be repeated more than 7 times as muscular fatigue prevented further discrimination. During this experiment care should be taken not to leave the trial person in front of the ring; i.e., before the 2nd experiment starts, either the current must be brought to zero or the trial person should leave the bundle of the lines of force.

Experiments with electric charges:

If a small electrostatic charge is brought to the left hand of the diviner without his knowledge, the pendulum deviates, the direction of deviation depending upon the sign of electric charge.

The same experiment can be repeated with a 4,5 volt pocket battery. As with experiments with divining rods (see p. 320) it takes usually a few seconds before the deviation occurs.

Experiments with horseshoe magnets:

Although this experiment cannot be carried out with the same degree of accuracy as those previously described, it was interesting to note that it also supports earlier results, i.e., pallomancy is a reality and not a fiction of easily suggestable people.

If a horseshoe magnet, without touching the arm, is placed with the south pole near the right hand (the diviner does not know which pole is used) a deviation occurs that is usually missing when the N-pole is used or an ordinary piece of iron. The explanation is not yet known but it might be related to the CARDIN *effect* (see p. 79). The horse shoe effect is most pronounced if the magnet is held opposite one of the surface arteries.

2. *Experiments for clarification of the physiological processes*

Similar to the experiments with divining rods described on p. 327-329 it was found that pendulum phenomena are more pronounced with considerably strained muscles than without; washing of the hands with electrolytes, in surrounding electrostatic fields, also increases the sensitivity. Insulation of the shoes and the contact between soil and diviner influence the pendulum phenomena in the same way as in the divining rod experiments. Not only electric and magnetic stimulation deviates the rod, but also other external forces such as electro-magnetic radiation, volatile compounds, etc. In other words the table on page 340 can be applied also to pallomantic phenomena. The influence of electromagnetic fields was not only established by making experiments with direct irradiation with electro-magnetic waves but the following electrostatic experiment also suggests a similar influence. If one ivory pendulum is suspended above an insulated plate and the diviner oscillates another ivory pendulum at a distance of 40 cm from the plate, no deviations occur. If the metal plate is charged to 100 V and the experiment is repeated, nothing occurs unless the arm of the diviner is very near to the plate. However, if the mechanically suspended pendulum oscillates above the electrically charged plate, the diviner at a distance of 40 cm notices a pronounded deviation of the second pendulum. The same experiment repeated without charging the plate has no effect. We are not quite certain yet whether or not suggestion plays a role in this experiment. But if the experiment can be established beyond doubt it might be due to the movements of an insulator (ivory pendulum) in an electric field causing electro-magnetic pulsations.

Both the *altitude effect*, mentioned on p. 367, and another experiment, which we discuss below, indicate the *influence of the atmospheric potential gradient.*

It was found that, if a diviner stands with an oscillating pendulum in a dowsing zone with his right arm parallel to the axis of this zone, a rotation of the pendulum occurs. If a high wooden table is placed

under the arm of the diviner, leaving a space of max. 10 cm between the globe of the pendulum and the table, and the oscillating movement is repeated, not a rotation but a simple deviation of the oscillating plane occurs. If we repeat this experiment every 30 minutes during a whole day we notice that the deviation in relation to a zero line (coinciding with the axis of the zone) takes place alternately to the right and left of this line. If the deviation to the right is called positive and to the left negative the following values were obtained (on February 4th, 1947):

9	hours	5	min	+ 22.5°	(first pos. max.)
9	,,	35	,,	+ 18.0°	
10	,,	5	,,	+ 12.5°	
10	,,	45	,,	+ 7.5°	
11	,,	15	,,	+ 4.0°	
12	,,	30	,,	— 2.5°	
12	,,	55	,,	— 15.0°	
13	,,	—	,,	— 20.0°	
13	,,	25	,,	— 24.0°	
13	,,	45	,,	— 17.5°	
14	,,	25	,,	0°	
15	,,	5	,,	+ 5.0°	
15	,,	40	,,	+ 16.0°	(second pos. max.)
16	,,	10	,,	+ 14.0°	
16	,,	30	,,	+ 7.5°	
17	,,	30	,,	— 17.5°	
18	,,	10	,,	— 20.0°	
18	,,	35	,,	— 10.0°	
19	,,	5	,,	+ 2.5°	
19	,,	30	,,	+ 7,5°	
20	,,	30	,,	+ 10.0°	
21	,,	—	,,	+ 12.5°	
21	,,	30	,,	+ 17.5°	(third pos. max.)
22	,,	5	,,	+ 10.0°	
22	,,	35	,,	+ 7.5°	
23	,,	—	,,	— 12.5°	
23	,,	30	,,	— 17.5°	

Very low temperatures (freezing) and snowfall were common during this period. It can be deduced from this example that a graphic representation of these deviations would show three positive peaks with intervals of abt. 6 hours.

It was found that on different days these curves are slightly displaced in relation to each other, e.g., the 2nd. max. on February 4th, 1947 being at 3.40 p.m., on February 6th, 1947 at 2 p.m.

Usually only three maxima occur, but in a few instances 4 have also been found (e.g., on February 6th, 1947) or only two (on June 8th, 1947).

The explanation of this peculiar behaviour of the pendulum is rather difficult. However, if we compare these curves with the curves of the potential gradient measured near houses (electrode effect, see p. 252) the similarity of both types of curves is striking. If the deviation is due to the influence of the potential gradient we should expect daily fluctuations which can be quite irregular near earthed objects, particularly in houses. The increase of the deviations of the pendulum, if the altitude above the ground increases, suggests a similar influence of the potential gradient (see p. 249), the potential difference between a point at great altitude and the earth being considerably larger than at low level.

All in all we are inclined to assume that *the atmospheric potential gradient is an important factor in pallomantic phenomena*. Although the reality of the general phenomenon of pallomancy could be established, it will take considerably more time to establish beyond doubt the other reported phenomena. A great amount of statistic data must be collected before a definite statement can be made.

B. Synthesis of the physical and physiological processes during pendulum phenomena

1. *Cause of pendulum deviations above non-living objects*

The pendulum movement is composed of two components perpendicular to one another, the fingers of the hand (holding the grip of the pendulum) and the arm. By regulating the muscular tension of the hand and arm the pendulum swings in one vertical plane. If the stiffness of the hand or arm is slightly altered by an external or internal impulse the equilibrium will be disturbed and the pendulum deviates. Depending on the phase-difference between both components the pendulum swings in a plane or makes elliptical or circular movements. The same phenomenon can be observed with not completely circular needles kept in a lathe. Vibration of the needle is linear, circular or elliptical, depending on the difference in the two main diameters.

In other words, all external and internal forces that can influence the number of motor units which are active during the stage of muscular equilibrium are able to disturb this equilibrium and will cause a deviation of the pendulum.

We have seen that all external forces that influence the divining rod seem also to effect the pendulum oscillations, with the difference that the muscular equilibrium during pendulum movements is considerably more labile than during divining rod experiments. In other words, considerably smaller changes in external forces can be registered with a pendulum than with a rod. On page 359 we have given a summary of the main causes of disturbance of the divining rod; this can also be applied to the pendulum. These causes are:

a. *Changes in skin potentials*, due to capacitive changes of the body in the neighbourhood of large conductors;

b. *Changes in the nature and number of absorbed aero-ions;*
c. *Changes in the magnetic field of the earth;*
d. *Potential differences between arm and earthed objects* or *electrically charged bodies.*
The fact that no reaction is felt with a divining rod above small diamagnetic objects such as copper or silver bowls in a dark room (otherwise electro-magnetic radiation could be responsible for it, see sub e) but pronounced deviations are obtained with a pendulum, suggests that the pendulum reacts in this case on the electric properties of a conductor. The arm (and insulated body) separated by the air from a conductor (copper bowl on the floor) could be considered as a condenser of which the lower conductor (bowl) is earthed. The arm differs in electric potential with the earth as a result of the ordinary skin potentials, but also because of the potential gradient in the atmosphere. The fact that the pendulum reaction is stronger if the vertical distance between the bowl and arm is increased, suggests that this potential gradient is even very important (for further evidence, see also above).
e. *Electro-magnetic radiation:*
Differential irradiation could stimulate the motor nerves according to one of the mechanisms discussed in the table on p. 345. Sources of stimulation during the ordinary pendulum experiments are:
1. natural sources of electro-magnetic radiation, i.e., sunlight. It could effect the arm particularly due to its infrared and ultra-violet rays either directly or indirectly, due to reflection.
2. artificial sources of electromagnetic radiation:
   α. infrared radiation of bodies differing in temperature with their surroundings;
   β. electric light, eithet directly stimulating or indirectly by reflection.

Two phenomena should be recalled in connection with pallomantic experiences:
1. *Photo-dynamic action of fluorescent dyes* (see p. 71): We have seen that certain drugs absorbed through the skin, particularly if applied in fatty base, might considerably increase the photo-sensitivity (both general and specific). The same applies to a great number of other chemical compounds (see p. 72). The phenomenon of *specific auto-sensitization* of diviners might be due to two causes:
   α. *Photo-dynamic sensitization* if the diviner is holding a drug in his hand;
   β. *Thalamic sensitization*, i.e., sensitization due to auto-hypnosis, blocking the function of the thalamus (see p. 387)

In this connection it is interesting to recall the amazing olfactory capacity of certain dogs, who are able to develop a specific sensitivity for certain odours after long dressure.

2. *Difference in intensity of reflected rays:*

It is well known that the percentage of light reflected by metal surfaces depends on the surface structure of the metal and on the wavelength of the light being used. This relationship to equally polished metal surfaces is shown in the following table. The figures indicate the percentage of light reflected.

Colour	Wavelength in m.μ.	Copper	Silver	Gold	Nickel	Allumi-nium
Ultraviolet	251	26	34	39	38	80
,, ,,	357	27	75	28	49	86
Violet	420	33	87	29	57	87
Yellowgreen	500	44	91	47	61	87
Red	800	89	97	95	70	87
Infrared	2,000	96	98	97	84	—
,, ,,	9,000	98	99	98	96	—

So far we have been unable to test diviners with monochromatic light (ordinary daylight is usually used). It would be interesting to see whether the above-mentioned data could be established with a human photo-electric cell. The failures often observed in critical tests might be due to variations in light intensity and dominating wavelength of the light, particularly if the experiments carried out after long intervals.
The observation of diviners that differently coloured papers or difference in historic periods of painting are reflected in the deviations of the pendulum seems to be supported by these theoretical considerations. This discovery of diviners, if proved correct, might find some practical application in the identification of paintings. Instead of a diviner, however, a very sensitive photo-electric cell should be used and light sources of known intensity and spectrum.

f. *Volatile stimulation:* In the case of volatile stimulation the pendulum is considerably more sensitive than the divining rod, not only because the pendulum registers smaller changes in discharging motor units of the motor nerves than a rod, but also because the oscillating movements accelerate considerably the diffusion of stimulating gases between the object and the nose (or mouth) of the diviner. The Russell-Stempel effect is therefore of greater importance for pallomancy than for rhabdomancy.

g. *Mechanical stimulation:* Apart from the ordinary strong mechanical stimulation, which naturally causes a disturbance in the pendulum

phenomena*, very small electro-magnetic forces seem to act on the pendulum as a mechanical force. In order to explain this we have to discuss briefly the mathematical studies of G.F.C. SEARLE (see Bibl. No. 1274), made in 1942. SEARLE calculated the force required to give a small acceleration to a slowly-moving sphere carrying a surface charge of electricity. This is actually the problem that must be solved if we want to calculate the mechanical forces exerted by an external field on a freely oscillating pendulum, composed of a conducting sphere and a conducting metal chain between hand and sphere, the sphere obtaining an electric potential equal to the skin potentials of the hand. The complicated calculation will not be repeated here, only the results:

1. A sphere with radius a, with an equally distributed surface charge q' moving along a straight line OA with a uniform acceleration f' obtains at a moment t the velocity U. The movement of this electrically charged sphere creates a magnetic field. Assuming that the static field on the sphere is not very much affected by the external fields, the force exerted on the movement of the sphere in the direction of the acceleration amounts to
$F_1 = \frac{-2\mu q f}{3a}$ (if μ = magnetic susceptibility, see p. 74)
2. If the sphere at first moves regularly with a velocity U_1 along an axis till the moment t, after which it moves with a changing velocity U_2, the force exerted on the sphere $F_2 = \frac{2\mu q^2 f}{3a}$

These forces are so small (as is known also from experimental work) that it seems to be excluded that under normal conditions the pendulum would deviate as a result of mechanical forces created directly by external electric, magnetic or electro-magnetic fields.

As with the divining rod, the mechanism of pendulum phenomena above non-living objects is probably due to a stimulation of the nerve endings near the surface of the human skin, which is conducted via the thalamus to the different sensorial areas. This excitation spreads to the motor areas and is relayed to the motor units of the motor nerves in the arms.

* In this connection it is necessary to realize that vibrations of the human body do not usually influence the oscillatory movements of the pendulum, a phenomenon known also of the seismograph pendulums which are practically unaffected by the movements of the suspension point as long as the period of vibrations of the earth is considerably shorter than the period of the pendulum. The same is generally the case during pendulum experiments, the period of the human body being usually considerably shorter than that of the pendulum. This explains that an experienced diviner can walk with an oscillating pendulum (along a straight line) without causing the slightest deviation of the plane of oscillations unless a dowsing zone is crossed. The same applies to the stability of a divining rod which is not influenced by the movements of the dowser.

2. *Cause of pendulum deviations above living organisms*

On page 357 we have discussed at length the causes of divining rod phenomena above living organisms. These explanations can also be applied to the pendulum phenomena. Only this difference can be noticed: whereas in divining rod experiments the trial person is never touched by the dowser, a common procedure in medical divining with a pendulum is that the diviner touches different parts of the body and observes the deviations of the oscillating pendulum in his right hand. In view of the fact that small artificial electrostatic charges brought on the left hand cause similar deviations, the magnitude and direction of the deviation being determined by the magnitude and sign of the electric charge, and the fact that the human body has skin-potentials on different parts of the body, varying in magnitude and sign, it is logical to assume that an experienced and sensitive diviner could register this pattern of skin potentials with an ordinary oscillating pendulum. Although this method might have great practical importance for a doctor during a quick survey, it could be recommended that an apparatus should be made available in hospitals, similar to that discussed on p. 197, which enables accurate objective skin potential measurements.

The deviations observed above urine (see p. 368) are probably due to volatile stimulation, the stimulation varying because of differences in sexual hormones, etc. in the fluid.

C. Causes of error

The different causes of error mentioned in the section on dowsing experiments can also be applied to pendulum phenomena. As the pendulum method is considerably more sensitive than the previous one it is even more advisable to take as many precautionary measures as possible during pallomantic experiments. The pendulum experiments have one particular handicap compared with those with divining rod. Whereas a dowser can walk a considerable time with a divining rod without becoming tired, the "fatigue phenomena" appear rather soon in pallomancy.

As soon as the first symptoms appear the deviations can no longer be trusted. A diviner who uses the pendulum a whole day and analyses a great number of patients is bound to obtain erroneous results and his analyses must be worthless. In view of the previous explanations it is also unnecessary to use a biologic analyser for this purpose. An instrument such as that described on p. 197 is definitely as sensitive as any diviner and can be constantly used in an objective way. Let us never forget however that if this method were generally applied to medicine it is thanks to the imagination of diviners, ridiculed for centuries, who showed us this road to an interesting goal.

D. Medical applications of pallomancy

We can be very brief here as most of the applications have been discussed in the conformable section on divining rod experiments and in the pages on pallomancy. The main applications of pallomancy are:

1. *The possibility of specific auto-sensitization*, which might enable a doctor to establish more accurately in each individual case the requisite dosage of drugs. A human being is not a machine and each person has his specific degree of sensitivity to drugs. Usually a doctor has very little chance to know exactly which dose is the most favourable. He will give one, two or three tablets a day whereas the optimum treatment of that particular organism might be obtained with, for example, $1^2/_5$ tablets. A scientific study of this subject is therefore of the greatest importance.
2. *The determination of the pattern of the electric field of the human body*, which as we have seen reflects all the physiological processes in the body. Once we have learned to interpret this pattern correctly we might predict certain diseases long before normal medical methods enable a diagnosis to be made. On the other hand strong artificial electric fields might influence this pattern and could have healing effects which otherwise are difficult to obtain.
3. *The regular study of the changes in electric fields of the body of women*
   a. might give an early clue for determination of pregnancy;
   b. might enable a doctor to predict the sex of the foetus;
   c. might indicate the most favourable period for conception (see exp. of Burr p. 198).

PART III: MAGNETIZER PHENOMENA (HYPNOTISM)

1. **Historical review**

In Bibl. No. 474, 476 and 1379-1412 a number of important publications on hypnotism have been compiled in which the problem of hypnotism has been studied from a scientific point of view. It is therefore superfluous to repeat all the results of the experiments carried out by the scientists. However, as the problem of hypnotism in general and the physiological processes during hypnotism in particular are partly responsible for a number of divining phenomena, it is necessary to summarize those experiments that are of direct importance for the problems of divining.

Hypnotism, in previous centuries better known as *magnetizer phenomena*, has been practised since at least 2000 B.C., both in China and the Middle East. The period of general development, however, started about 1775 after Mesmer (1734-1815), doctor in Vienna, later in Paris, claimed he could cure diseased people with his "magnetic force", a kind of radiation, later called OD or *Odic force* by Baron Carl von Reichenbach

(1852). It was a term derived from the Germanic deity *Odin*, signifying a power penetrating all nature. A committee in Paris, however, composed of LAVOISIER and BENJAMIN FRANKLIN a.o. decided in 1784 that *Mesmerism* was purely charlatanry. MESMER left Paris but his pupil MARQUIS CHASTENET DE PUYSÉGUR continued his studies. He discovered in 1784 the *artificial somnambulism*. A second period of development started about 1830 in England and India. In England the great leader of Mesmerism was JOHN ELLIOTSON (1791-1868) a famous doctor, since 1831 Professor in Medicine in London. The attitude of the university council compelled him to resign in 1838 and he concentrated privately on the study of Mesmerism. In his journal "Zoist" he described several cases of painless amputations of legs, breast, etc., without using anaesthetics, by bringing the patients in a hypnotic sleep.

In India JAMES ESDAILE (1808-1859), Surgeon at the Indian hospital at Hooghly, succeeded in painlessly performing hundreds of serious operations without anaesthetics. A committee appointed by the Governor of Bengal confirmed his successes and enabled him to continue his work in a larger hospital in Calcutta. At least 161 serious operations were carried out, using hypnotic sleep, without mortality and still he had to complain bitterly (Bibl. No. 1386a) of the unscientific attitude and mendacious criticism of his colleagues in this period.

The actual founder of modern Mesmerism is JAMES BRAID (1795-1860) a famous surgeon and eye specialist in Manchester, England. He laid the first theoretical foundations of scientific Mesmerism, to which he gave the name *hypnotism* (in 1841). He could prove that hypnotic phenomena had nothing to do with magnetism. The results of his experiments are laid down in Bibl. No. 1381 a. A French translation appeared only in 1884, which explains why, independently of BRAID, Mesmerism in France was rediscovered by LIÉBEAULT (1823-1904), a doctor in Nancy. Although LIÉBEAULT first believed in magnetism as being the cause of Mesmerism, later studies convinced him that suggestion was mainly responsible. Great opposition from his colleagues ended up in his being ostracized by the Medical Society in Nancy. Only one copy of his book "Du Sommeil et des états analogues, considérés surtout au point de vue de l'action du moral sur le physique", published in 1866, was sold. This state of affairs changed suddenly in 1881 after LIÉBEAULT succeeded in curing a patient who for 6 years had suffered from sciatica and who had been treated in vain for six month by a famous doctor of internal diseases at Nancy, Prof. BERNHEIM. Soon BERNHEIM became one of LIÉBEAULT's pupils and in 1884 he published his famous book "De la suggestion et de ses applications à la thérapeutique". LIÉBEAULT then became a man with international repute. In 1891 he was honoured by the appointment of honorary president of the "Société d'Hypnologie et de Psychologie de Paris"; in 1896 he became honorary member of the Dutch Society of Psychiatry and Neurology. Famous pupils of LIÉBEAULT, beside BERNHEIM, were: Prof. BEAUNIS, prof. LIÉGEOIS,

Dr Bramwell (England), Dr Van Renterghem (Holland), Dr Delboeuf and Van Velsen (Belgium). Hypnotism rapidly spread over Europe. In Germany Haidenhain, Preyer, Dessoir and Moll were leading scientists on hypnotism; in Switzerland, Forel; in Sweden, Wetterstrand. In France the "Revue de l'Hypnotisme" appeared; in Germany, "Zeitschrift für Hypnotismus".

However, hypnotism was generally accepted as a scientific treatment only after the last war, after Prof. Nonne (Germany) had succeeded in curing soldiers who suffered from shell-shock. In the U.S.A. during the last 30 years, hypnotism became a subject of psychological research, particularly because of the work of Dr L. E. Young. In Holland it has been mainly developed on a scientific basis by Prof. Carp and Dr Stokvis of Leiden University and Dr Koster of the university of Amsterdam. Hardly any doctor at present dares to deny the great importance of hypnotic treatment for mental diseases and it has taken almost 4,000 years before the truth found by the old Chinese, Indians and Assyrians, after being ridiculed by most prominent scientists of the last 20 centuries, has been recognized. It is for this reason that we have given this short historical review; let it be a warning to the scientists of the 20th century who still deny the existence of divining phenomena.

2. Summary of characteristic hypnotic phenomena

Scientists readily use the expression "suggestion", but if they are asked what suggestion means and how they explain the detail processes described by this word, which covers up only a certain lack in our knowledge, very rarely is even a vague answer given.

It is true that hypnotism or magnetizer phenomena are mainly due to suggestion, but if we think of the complex physiological process of a painless amputation of a leg during hypnotic sleep, we realize that we enter into a field of research that is still for a great part terra incognita. Similar fields are the stigmatization and fakir phenomena, which we discuss p. 394.

Although a complete explanation cannot yet be given, a general outline of the physical and physiological processes is possible. Before giving this explanation a short summary is necessary of the characteristic phenomena during hypnosis. The subject must be divided into two parts: hypnotic phenomena with man and with animals.

A. Hypnotic phenomena with man

It is well known that a person during hypnotic treatment can be brought in a kind of sleep that can be divided into three stages: *somnolence:* condition of drowsiness; *hypotaxis:* light sleep; *somnambulism:* very deep sleep.

2. A. 1. Methods used for hypnotizing people.

a. *Degree of hypnotability:*

1. According to KOSTER every person can be hypnotized, if the correct method is applied, except lunatics and imbeciles. Of 1,011 patients, only 27 could not be hypnotized by LIÉBEAULT; BERNSTEIN estimated the number of non-hypnotizable people at less than 20%.
2. Hysterical persons are generally difficult to hypnotize against their will; normal persons are the most easily hypnotized; cyclothymes are more easily hypnotizable than schizothymes (according to KOSTER and HULL).
3. According to KOSTER, BRAMWELL and WINGFIELD there is practically no difference in hypnotizability between males and females.
4. Children above the age of three are more easily hypnotizable than adults (conclusion of KOSTER, LIÉBEAULT, WETTERSTRAND, BRAMWELL, a.o.). The age of seven is usually the time of maximal hypnotizability; this decreases till the age of abt. 16, thereafter remaining rather constant.
5. The social position of man does not seem to influence the degree of hypnotizability.
6. Anaemic persons are usually more easily hypnotizable (acc. to LIÉBEAULT and VAN RENTERGHEM).
7. Whether a person is usually good sleeper or not does not seem to have any influence (acc. to KOSTER).
8. Every person who refuses to be hypnotized and who knows from previous experiments that he could not be hypnotized can resist every hypnotizer.
9. Hypnotic sleep can be caused at a distance by speaking through a telephone, radio, by television or by a letter.
10. Nervous excitement or fear at being hypnotized makes a person less sensitive to hypnosis.
11. The hypnotizability increases if a person has been previously hypnotized. According to KRUEGER (Bibl. No. 1393) the time required for hypnosis decreases from abt. 200 to 80 seconds (conclusion drawn from 5 trial persons, each being hypnotized 8 times in succession). Below a certain minimum value no further decrease occurs. If the treatment is interrupted for several weeks the *hypnotic time* (i.e., time between beginning of experiment and first observable vibration of closed eyelids) is considerable greater again.

b. *Methods used for hypnosis:*

A *suggestive sphere* must first be created. The patient lies on a bed or settee; the room must be quiet and the light subdued; the word hypnosis must be avoided, the hypnotizer speaking only of sleep. All tight clothing must be removed. The hypnotizer usually sits beside the head of the person. Different methods can be applied at this stage:

1. *Fixation method of* BRAID: The hypnotizer holds a small object abt. 20 cm obliquely above the eyes of the patient. The patient is told to look at the object and concentrate on it without speaking. After a few minutes (sometimes a few seconds) the eyes become tired. The hypnotizer repeats the words "your eyes are getting tired" and slowly the object is moved towards the feet of the patient. Then the hypnotizer says convincingly: "you are sleeping now, your eyelids remain closed and cannot be opened". For further details of this method see Bibl. No. 1396 a.o. As soon as the patient is in hypnotic sleep the eyelids show a characteristic vibration. As will be discussed later, this method is based on the observation that inhibition of the cerebral cortex, required for hypnosis, occurs after continuous excitation of the nervus opticus and the nervus oculomotorius (regulating the movements of the eye).
2. *Method of verbal suggestion of* LIÉBEAULT *and* BERNHEIM: This method is usually used in combination with the pure fixation method (without speaking). As soon as the hypnotic stage is reached the hypnotizer puts his hand on the forehead and with the other hand he presses first the left arm of the patient, then the right arm, then the left leg and finally the right leg, continuously suggesting "your left arm is terribly heavy and it is impossible to lift it."
3. *Acoustic method:* Certain hypnotizers use the noise of an electric machine, etc., as a means of hypnotizing people. It is based on the fatigue phenomena of the excited nervus acusticus.
4. *Fascination method of* FOREL *and* KRONFELD:
   Here the patient and doctor look in each other's eyes, a method only recommended for children.
5. *Method of "passes" of* MESMER: The hypnotizer slowly moves his hands from the head to the feet of the patient; this movement (called "passes") is repeated continuously.
6. *Method of fractional hypnosis of* VOGT: During the hypnotic treatment the doctor continuously asks the patient about his feelings in order to prevent suggestions which cannot be fulfilled. This method is not generally recommended by hypnotizers.
7. *Method of colour contrasts by* LEVY-SUHL: This method is also practised by STOKVIS and KANDOU, who use two differently coloured strips stuck on a piece of cardboard, at a distance of 5 mm apart. After concentrating on this colour contrast the patient's eyes become tired.
8. *Method of narco-hypnosis:* The use of drugs to create hypnotic phenomena is described on p. 148.
9. *Kataplexis or fright-hypnosis:* A name given by PREYER for a semi-hypnotic condition that arises if a person is suddenly frightened.

Only after the patient is in a quiet hypnotic sleep can the doctor begin his therapeutic suggestions. During the first treatment this lasts for 15-30 minutes, later 10-20 minutes; in certain cases hypnotic sleep for

1-3 hours has been recommended; the average period of treatment lasts for 3-4 months, with 3-4 treatments per week.

In order to end the hypnotic sleep the doctor (for example) asks the patient to count and tells him that he will be awake when he reaches the number three. After he wakes up, he should remain on the settee for 5-10 minutes in order to be completely rested.

It is evident that hypnotic treatment should be done only by fully qualified doctors as permanent psychic damage can otherwise be caused by the hypnotizer.

So far we have discussed different methods of causing hypnotic sleep with the help of a second person. Certain people, however, are able to bring themselves in a similar hypnotic condition by *auto-suggestion*, particularly with the help of the fixation, acoustic or colour contrast methods. The hypnotic condition often ends up in ordinary sleep which lasts for a period more or less dependent on the will-power of the person who determines at the outset the time interval which should elapse before he wakes up. This is closely related to the phenomenon, observed with certain people, who are able to wake up during the night at a certain hour. In para-psychology it is known as the *head-clockwork phenomenon*.

c. *Methods for discovering possible simulators:*

Several symptoms have been found that enable an experienced doctor to differentiate between real hypnotic sleep and simulation:

1. the rapid vibration of the eyelids which cannot be imitated artificially, certainly not for a long period;
2. in case of hypnosis the eyelids close very slowly, during simulation the action generally occurs too quickly;
3. the whole face of the hypnotized person takes on the appearance of a peculiar mask;
4. the hypnotized patient shows the phenomenon of *katalepsis*, i.e., if the arm or leg of the hypnotized person is lifted it remains for a long period in this position without trembling; this is impossible for a simulator. It shows up particularly if the arm or leg is connected to an automatic registrating instrument;
5. if the experiment is carried out long enough, the simulator will become bored and he might turn his body, arm or leg, which hardly ever occurs in the hypnotic condition;
6. the hypnotized person does not feel ordinary pain reactions provoked, for example, with a sharp needle;
7. the electro-encephalogram during hypnotic sleep is different from ordinary sleep (see p. 148 and 387).

Other typical hypnotic phenomena, which we discuss in the following pages, are characteristic of a true hypnotic sleep.

2. A. 2. Differences between ordinary and hypnotic sleep

Braid and Bramwell were the first to recognize pronounced differences

between ordinary and hypnotic sleep. Their observations were extended by later research workers. The main differences can be summarized as follows:

A. During hypnotic sleep *the patient does not wake up* as a result of noises, as would happen with ordinary sleep.

B. A person in hypnotic sleep *remains in an immovable position even after hours*, whereas in ordinary sleep he moves after a certain period.

C. A hypnotized person *reacts to acoustic stimulation* in a normal way except that the reactions are slower; e.g., a person can be ordered to take off his shoes. These actions are well coordinated, which is not the case if the same verbal suggestion is tried on an ordinary sleeping person.

D. 1. A continuous contact remains between the hypnotizer and the patient known as *report*; this contact is missing with an ordinary sleeping person.
2. This report is not restricted to the hypnotizer himself; other persons can usually make certain suggestions.
3. The report can be cut suddenly by previous strong *auto-suggestion;* e.g., if the patient has asked to finish the experiment at 3 o'clock, and the hypnotizer suggests at that hour that the sleep will continue, the report is usually broken off suddenly; also if the patient before the experiment has agreed to follow different suggestions except one, he will not follow this latter in a hypnotic sleep and the report is broken off temporarily.

E. *Post-hypnotic-amnesy* (i.e., the feeling of the hypnotized person of having slept after waking up from a deep hypnotic sleep) occurs in only 14% of the cases of hypnotic sleep. Usually the person does not know what happened (discovered by PUYSÉGUR).

F. The *reflexes* are different in hypnotic sleep.
1. The pupils are narrow in ordinary sleep, wide during hypnosis (this difference in *eye reflex* was discovered by BRAID).
2. The *knee-reflex* is considerably reduced or practically missing during sleep. According to BASS the decrease amounts to 60% (average of 12 900 observations). During deep hypnosis no decrease in reflex was observed.
3. The *reflex of the soles of the foot* changes during sleep, whereas it remains unchanged in hypnotic sleep (unless the hypnotic sleep gradually changes into an ordinary sleep).
4. The *acoustic reflex* decreases, max. 2%, during hypnotic sleep; during ordinary sleep it reduces rapidly 80% or more. The

experiments were carried out by BASS who suggested to his trial person that he presses on an electric bell as soon as he heard a weak acoustic signal.

G. The *electro-encephalogram* is different (see p. 149). In trance the amplitude increases enormously; after a Fourier analysis the hypnotic curve is angular, whereas the normal curve is sinusoidal.

2. A. 3. Other characteristics of hypnotic sleep

A. *Restriction of consciousness:* the hypnotized person has ordinary sensorial observations, but coordinative associations and reactions occur only after the hypnotizer has suggested something and forces the patient to pay attention to a certain observation.
Under normal conditions restricted consciousness may also occur:
1. *Pre-occupation:* a person might ask for food, although he had had a meal only a short while ago.
2. *Analgesie* (i.e., the loss of sense of pain): if people are seriously wounded without knowing they might not feel anything, but as soon as they notice the wound an unbearable pain occurs.

B. *Increased suggestibility:* the suggestibility increases enormously in hypnotic sleep; this shows up in different ways:
1. with 80% of people the post-hypnotic sense of touch (i.e., the sense of touch measured after hypnosis, during which greater sensitivity was suggested) is 22% higher (acc. to KOSTER) than in case of suggestion without hypnosis;
2. experiments of HULL and HUSSE, with people standing upright, and to whom is was suggested with a gramophone record that they fall forward, indicated that with normal people in hypnotic sleep the suggestibility is abt. twice as large as under ordinary conditions.

C. *Inhibition of the sympathetic nervous system:* hypnosis has an appeasing inhibiting action on the sympathetic nervous system, similar to the influence of ordinary sleep. Hypnosis is therefore called a BRAIN *stem sleep.*

The previous characteristics of hypnotic phenomena enabled KOSTER to give the following *definition of hypnosis: "Hypnosis is a state of mind of restricted consciousness during which the suggestibility is increased, the spontaneous thoughts and voluntary impulses are decreased and the sympathetic nervous centres are inhibited."*

2. A. 4. Examples of hypnotic command during sleep

Different cases have been reported by VAN RENTERGHEM a.o. about suggestion made during ordinary sleep:

A. Van Renterghem suggested to his son during his sleep that he recite a poem next morning at breakfast. The recitation took place although the boy was fast asleep when the command was given.
B. Van Renterghem suggested to a sleeping friend in a train, that he owed v. R. 5 guilders. Later in the day the friend insisted on paying the 5 guilders, although he did not in fact owe this money. He refused to believe that his behaviour was due to suggestion.

2. A. 5. Sleep-walking (spontaneous somnambulism)

Tuke and Koster consider sleep-walking as a special form of hypnotic sleep. Whereas in ordinary sleep all muscles are relaxed and coordinated movements are excluded, during sleep-walking the same coordinated movements occur as during hypnosis. The studies of Tuke (Bibl. No. 1409 a) revealed the following peculiarities:
a. sleep-walking has nothing to do with *epilepsis*, as has often been assumed;
b. idiots and imbeciles are rarely sleep-walkers;
c. crimes are very rarely committed during sleep-walking. A case was reported in 1868 of a father killing his child during sleep-walking, thinking that he was hunting a boar; Koster reported a case of a boy who always committed arson during sleep-walking and who slept quietly again when the fire was discovered. However these cases are exceptions.

An interesting case of sleep-walking was reported by Tuke. A sergeant in the army who was sleep-walking went to a desk and started to write a letter. Every time that he stopped writing the letter was removed and replaced by another paper. Finally on the 10th sheet of paper he placed his signature. He re-read the white sheet, placed dots and other corrections on it (where according to the other 9 pages it was required).

B. Hypnotic phenomena with animals

Many examples are known of so-called dressure of animals, during which a single grasp in the neck or on the head of an animal is sufficient to create a temporary condition of *katalepsis*, e.g., lions lying as dead, crocodiles who suddenly become stiff and no longer dangerous, etc. Semi-hypnotic conditions, *kataplexis*, if an animal is frightened is well known, particularly with chickens, rabbits, etc. Fish remain apparently dead in a net or if they are suddenly plunged into the water belly upwards. Pfungst succeeded in bringing monkeys into a hypnotic condition by gesticulation at a distance.

Chickens (and certain insects) show these *immobilization reflexes* during *sexual intercourse*, e.g., immediately after the cock has pecked the chicken a few times in the neck. For further details on animal hypnosis see Bibl. No. 1410.

3. Explanation of the physical and physiological processes during hypnosis

We have seen on p. 146 that in *light sleep* the α waves in the electro-

encephalogram tend to become slower, larger and less regular in form and frequency. In *deep sleep* they are usually absent, although irregular groups of slow large waves may occur at intervals; the FOURIER analysis shows sinusoidal curves. In the *hypnotic sleep* (see p. 149) and *trance* the amplitudes of the α waves increase enormously; a FOURIER analysis shows an angular curve. Studies of BERGER, KOOPMAN, and FRANKE (Bibl. No. 451, 474 and 476) revealed that application of drugs could also create two types of diagrams, depending on whether the drugs affected only the cerebral cortex or the brainstem (see p. 148 and 149).

On p. 148 we explained that a state of unconsciousness (coma) is caused by two different processes:

1. if all the parts of the cortex are too strongly activated as a result of blockading the *thalamus*, which is the main relay station for the transmission of cortical impulses; lack of sufficient differential stimulation of the cortex prevents us from observing consciously (*theory of* PAVLOV);
2. if all activity of the cortex is completely stupefied.

The first case is the brain-stem or hypnotic sleep, the second the ordinary sleep. The actual cause of sleep is unknown, although different theories have been advanced:

1. One theory assumes that sleep may be due (at least in some instances) to fatigue phenomena as a result of the action of chemical products of muscular activity, e.g., lactic acid.
2. Another theory assumes general fatigue phenomena in the nerve fibres conducting the sensorial excitations to our brains, as a result of poisonous chemical products which originate during nervous conduction (see p. 142) and which at a certain moment can no longer be decomposed by the blood.
3. PIÉRON assumes that a specific cerebral toxin (*hypnotoxin*) is the cause of sleep. He based his theory on the observation that when cerebrospinal fluid from a fatigued animal is injected into the cerebral ventricles of a normal animal, the latter shows signs of drowsiness and falls asleep.
   Studies by HARRISON, DEMOLL, BERGGREN, a.o. indicated that the *hypothalamus*, part of the brain-stem which has considerable influence on the sympathetic nervous system (see p. 131 and 396), contains an important part of the central neural mechanism involved in sleep. Both electric and chemical excitation (e.g., with $CaCl_2$) of this part of the brain seems to create an ordinary sleep condition.

In this connection it is interesting to mention the experiments of RANSON, who demonstrated that lesions of the hypothalamus may render animals somnolent; if the lesions were confined to the thalamus somnolence did not occur.

Different external causes seem to excite the thalamus to such an extent

that a kind of *tetanus* occurs (see p. 168). We revieved these causes above. They are:

1. *Acoustic stimulation:*
   a. noise of an electric machine (exciting the nervus acusticus)
   b. verbal and fright hypnosis; this does not need to blockade the whole thalamic function but could influence only certain parts of the cortex, e.g., part of the cortex, which regulates the will-power impulses.
2. *Visual stimulation:*
   a. fixation method
   b. fascination method
   c. method of colour contrasts
   All three methods are based on continuous excitation of the nervus opticus and n. oculomotorius.
3. *Chemical stimulation: narco-hypnosis*

In the case of animals Spiegel and Goldbloom could prove that rabbits do not need a super-stimulation of the thalamus opticus and striatum, but only of the nucleus ruber.

It is evident that inhibition of that part of the cortex which includes the will-power facilitates the free function of other parts of the cortex;, in other words, the sensitivity to external physico-chemical impulses (either electric, magnetic or electro-magnetic) will increase enormously. This explains the often-ridiculed methods, generally applied by diviners in dowsing, experiments on telepathy, clearsightedness, etc., that enable the diviner to develop an autohypnotic condition by using one of the above methods; this state of mind automatically enormously increases his receptivity.

Up till now we have summarized only the main causes of *hypnotism without direct contact* between hypnotizer and patient. The so-called *magnetizers* place their hands on certain parts of the body that are diseased and claim that they are able to cure patients by this treatment. In the case of succesful treatment it is always explained as being due to suggestion. However on p. 175 we discussed the telephysical phenomena and we gave a review of different causes of skin potentials (on p. 174). Certain people seem to possess extremely high skin potentials and objects or water can be electrified by them (see p. 177, "magnetized water"). The electric charges are concentrated on the skin and the density is greatest near the strongest curved parts (see appendix I, p. 432). On p. 182-183 we gave a review of the influence of static electricity on the animal body, particularly under favourable atmospheric conditions. All these facts together suggest that trustworthy magnetizers do not influence patients only by suggestion, but also directly by electrostatic stimulation. This problem has not yet been studied from a scientific angle. However, with an apparatus as developed by Burr and Northrop (see p. 197) the assumption could easily be checked.

PART IV: SENSITIVITY FOR DIRECTION OF ANIMALS

A fourth group of phenomena, belonging also to the divining phenomena can be summarized under the heading "*sensitivity for direction of animals.*"

This sensitivity has been observed particularly with birds and a few other animals. Other groups of animals have a similar sensitivity which, however, can be brought back to normal sensorial observations, such as smell, visual osbervations, etc.

It is not within the scope of this publication to give a complete review of all reported phenomena connected with this special gift of certain animals. Those interested are referred to the publications mentioned in Bibl. No. 1413-1430 and in Appendix II. An exception will be made for one particular case reported by the secretary of the "Leiden carrier-pigeon Society" of pigeons belonging to the Dutch captain of a Rhine barge. The pigeons were taken away from the boat at 7 o'clock in the evening. That night at 12 o'clock the ship left for Germany and arrived the next morning at a German port, where it was anchored between several other Rhine barges. That same morning at 10 o'clock the pigeons were released from their cage in Holland and arrived a few hours later on the ship of the owner in Germany. The pigeons had no difficulty in finding the boat between all the other barges.

Extraordinary cases were reported during the war, e.g., after the landings in Sicily, from where carrier-pigeons flew straight back to Marocco although they had never before made the trip. Similar striking cases have been reported from wild birds*.

All these observations indicate that certain birds have the capacity to locate both moving objects and fixed locations irrespective of the fact whether the landscape through which they have to travel is known to them or not.

Three observations suggest that the sensitivity for direction is the result of the sensitivity of birds to electrico-magnetic and physico-chemical phenomena.

1. It has been noticed that carrier-pigeons in the neighbourhood of big radio-transmitters are unable to find the direction which they have to follow in order to return to their base. During the war experiments were carried out with transmitters on which the pigeons were placed. Without transmission of waves the birds would fly directly to their place of origin; as soon as the transmitters started working they lost this capacity. This could be the result also of the influence of HERTZIAN waves on the general nerve-condition of animals (see p. 284), but the following observation does not seem to allow a similar explanation.

2. For at least 24 hours after heavy snowfall carrier-pigeons lose their sensitivity for direction. Gradually it returns, although the landscape

* According to F. C. LINCOLN (see bibl. Appendix II) a golden plover performs the remarkable feat of navigating 3,000 miles from Alaska to the Hawaiian Islands with no landmarks over the vast Pacific Ocean.

remains covered with snow. On p. 246 we have seen that whirling up of snow creates considerable electric charges and that as a result high positive and negative potential gradients have been reported during snowfall.

3. On p. 73 we described the experiments of BENOIT (Bibl. No. 1413a), MYERSON and NEUSTADT (Bibl. No. 1423a), ROWAN (Bibl. No. 1423b) and BISSONETTE (Bibl. No. 1414a) on the influence of ultraviolet waves on the sexual activity of vertebrates as a result of increased androgen secretion, one of the important sexual hormones. On p. 70 we have seen that the amount of ultraviolet received in summer is higher than in winter. All these factors together might influence the process of migration of birds and their capacity of finding the direction towards the place of migration.

Different theories have been advanced to explain this sensitivity for direction of animals, of which only four seem to take into consideration a physical cause of this psychic capacity.

1. ISING ascribes this sensitivity of birds to the influence of the *coriolis force* (i.e., forces due to the rotation of the earth causing the deviation of N.S. currents) on fluids of the semi-circular canals of the inner ear; this enables them to determine their direction of flight and latitude (see Bibl. No. 1420).

2. The author (Bibl. No. 1448, p. 120) assumed that the sensitivity for direction might be related to an unknown radar instrument in the brains of birds, similar to acoustic radar phenomena in the ear of bats (see p. 110). The existence of such an organic radar instrument could explain the sensitivity of birds to electric phenomena.

3. The author mentioned (in Bibl. No. 1448, p. 120) the possibility that bird navigation may be due to a great sensitivity of birds to variations in the magnetic field of the earth. Recently we discovered that the magnetic theory had been advanced by C. VIGUIER in 1882 and by A. THAUZIES in about 1898 (see Bibl. App. II).

4. A number of scientists suggested that birds are sensitive to variations in gravity as a result of variations in the earth's tadius.

These few examples indicate the great importance of a scientific study of the causes of sensitivity for direction of animals. Such a research might reveal unknown phenomena in the brains of animals that might throw new light on the mental processes of man and on problems such as thought-reading and telepathy.

The salmon and the eel also seem to possess a similar capacity for direction finding. The mystery of the salmon and the eel (belonging to the class of the Cyclostomata, phylum Chordata) is even more difficult to solve than the previous problems.

1. The young *salmon* spends years at sea and is able to return to the tributary of the river where he was born. If he is transferred to another tributary he will fight his way down, comes back to the main stream and finds his own tributary.

2. The *eels* migrate at maturity from all ponds and rivers from Europe across thousands of miles of ocean to the deeps near Bermuda. There they breed and die. The young eels start back and find the pond where their parents came from (it is always the same species which return). No American eel has ever been caught in Europe and no European eel in American waters.

Not only animals, but also "man" seems to possess this sensitivity for direction, which capacity degenerates in more highly civilized individuals. The incredible capacity of certain people, particularly negroes or papuans, for locating themselves in the middle of dense jungle country, might be the result of similar phenomena.

This short summary of the sensitivity for direction of living organisms may suffice to stress the importance of the introduction of physical research methods in the study of divining phenomena*.

PART V: PSYCHICAL PHYSICS (see Bibl. No. 1431-1472)

In previous chapters we have reviewed that wonderful web of electro-magnetic forces which seem to regulate all living processes on earth. It is this web of forces, described previously by the author in his book "*The Religion of the modern Scientist*" (Bibl. No. 1448), that asks for more extensive physical research. The advancement of this study has been slow, partly because of the great number of conscious or unconscious charlatans, who are interested in this type of work, preventing the serious scientist of being connected with such research projects in the paranormal field, and partly because of the lack of cooperation between scientists of different branches of natural science. The problems of divining and the para-psychological problems in general are so extremely complicated that it is impossible for any, even the most gifted research worker, to study this problem individually. Only if a group of scientists worked together in one laboratory in close cooperation might these most complex and fascinating problems of modern science be solved. We have endeavoured to demonstrate that the solution is not only of academic importance. They might throw a completely new light on the medical, physical, chemical and biological sciences, the bearing of which is difficult to estimate at present, but the influence of which will without doubt be considerable.

The study of this large field of so-called *para-normal phenomena*, which have partly been included in *meta-physics*, partly in *parapsychology homoeopathy*, etc., has been given by the author the name *psychical physics*. It could also have been called biophysics, but existing biophysical laboratories do not concentrate on the use of physical methods

* After completion of the manuscript in Aug. 1947, a most interesting article was received from DR. H. L. YEAGLEY on the causes of bird navigation. A summary of his research has been compiled in Appendix II p. 436-439.

in the study of psychical phenomena. The vitalists strongly object to the name *psychical physics* as they are convinced that psychical phenomena are ruled by a group of laws fundamentally different from the physical laws. The author in his publication (Bibl. No. 1448) has shown that such a distinction is not based on facts. Psychic phenomena can be approached by using physical and physico-chemical methods.

Since the foundation of the "Society for Psychical Research" in London in 1882, many institutions in France, Germany, England, U.S.A. and Holland have collected a great number of para-psychological observations which have been summarized by the author in Bibl. No. 1448, p. 212-237 (see also Bibl. No. 1431-1434). However, really scientific physical research on the deeper causes of these phenomena has been almost negligible, a few exceptions being the excellent studies of Dr OSTY in Paris, PRICE in London and KOOPMAN and Dr FRANKE in Amsterdam (see Bibl. No. 1434a-1451). Gradually more and more scientists in different countries have become interested in the problem of psychical physics. Although most of the observed phenomena still await an accurate scientific proof of their reality, such an enormous amount of evidence has been collected, that it is worthwhile establishing laboratories for psychical physics in different countries. Amongst the subjects to be studied the following are of primary importance:

1. *Study of physical and physiological processes in brains and body of para-normally gifted persons:*

   a. encephalographic research (see p. 148);
   b. study of psychokinetic phenomena;
   c. study of the cause of sensitivity for direction of animals and capacity of returning to their dwelling place;
   d. study of physiological processes of "stigmatic phenomena";
   e. study of physiological processes during "fakir phenomena."

2. *Study of the influence of magnetic and electrostatic fields on living organisms in general and on para-normally gifted persons in particular* (see also p. 112, emanometer of BOYD).

3. *Study of the fluctuations of skin potentials of living organisms and para-normal persons in particular* (see p. 181):

   a. Study of influence of changing skin potentials (due to external fields) on physiological and psychic processes;
   b. Study of prediction of diseases by skin potential measurements (see p. 198 and 371);
   c. Distribution and magnitude of skin potentials during para-normal phenomena (hypnotized people, etc.);
   d. Mutual electric influence of one living body on another (see also divining rod experiments of TROMP);
   e. Influence of drugs on skin potentials (see also photo-dynamic action, p. 71).

4. *Study of the infrared radiation on the human body* (see p. 120)
   a. Influence of drugs on infrared radiations of the human body (see p. 88)
   b. Influence of terrestrial radiation on human radiation;
   c. Influence of human radiation on other living organisms;
   d. Thermal effect accompanying para-normal phenomena (see p. 119).

5. *Study of telepathic phenomena* (see sub 1).

6. *Study of psychoscopic phenomena* (also known as psychometric phenomena) (see also p. 303 and 359, shadow phenomenon).

7. *Study of kallipedic phenomena*

8. *Study of cosmic influences on living organisms:*
   a. using capillarity phenomena (see p. 94);
   b. using crystallization phenomena (see p. 95);
   c. using periodical precipitations (see p. 49).

9. *Study of homoepathic concentrations* (see p. 86—93).

10. *Study of the influence of the soil on man*

A laboratory for psychical physics that would study these problems should consist of a team of at least 10 scientists: a *physicist* (with technical experience), a *pharmacologist* (specialized in physical chemistry), a *biologist* (specialized in electro-physiology of plants and animals), a *physiologist* (specialized in electro-physiology of man), a *brain-specialist* (specialized in encephalographic research), a *neurologist*, a *psychologist* (specialized in experimental psychology), a *para-psychologist*, a *geophysicist* (specialized in meteorological problems) and a *scientific coordinator* (at the same time leader of the laboratory of psychical physics). They should be appointed for a period of 5 years, as only after such a trial period would it be possible to determine the necessity of continuing the research; once this necessity is established, the scope of future research can then be planned.

Most of the titles of the subjects to be studied, mentioned above, are self-explanatory but a few need further explanation.

Psychokinesis (sub 1 b): It comprises a group of phenomena, which indicates the influence of mind on matter, and which was described for the first time in 1942 by the American psychologist, JOSEPH BANKS RHINE. During his experiments a number of college students rolled dice down a specially built washboard chute, at the same time concentrating on a special number of the dice. After 300,000 experiments it was found that a greater number of special dice numbers was obtained during concentrated thinking than without. His experiments were repeated in 1946 by Prof. G. MURPHY of Columbia University. After 31,104 attempts it was found that during the will-power test 171 more hits were

obtained than can be expected in case of pure chance. The experiments were carried out with 54 students, but only 15 of the 54 accounted for this good score; women obtained much better scores than men; after the first few rolls, each student obtained consistently fewer and fewer hits. The experiments were repeated in England but without success but this does not need to disprove the existence of psychokinetic phenomena. A similar failure of *telephysical experiments* (see p. 175) was found to be due to specific atmospheric conditions in England, i.e., the humidity was too high. We fully agree that the results of Rhine and Murphy seem to be incredible and one is inclined to think of experimental errors. Still we should not like to go as far as to deny a priori the possibility of the influence of the electric field of man on falling objects in his neighbourhood and we definitely consider it worthwhile to repeat these experiments under rigid control of a number of scientists.

Stigmatic phenomena (sub 1 d): It is wellknown that with certain religious people and at certain fixed periods (mostly Fridays) 5 wounds appear on the hand, each with a hard centre. The wounds bleed strongly, but the bleeding suddenly stops and thereafter no trace of the wounds can be found. This group of *religious stigmatization* phenomena was observed with Theresia Neumann, Louise Lateau, a.o. Different other types of stigmatization are known (see Bibl. No. 1448, p. 228-230), e.g. *stigmatization of "possessed ones"*, which is characterized for example by the appearance of a letter on the skin of the person. Recent examples have been reported by Dr B. Stokvis from the Laboratory of Experimental Psychology at Leiden University (Holland). The physiological processes during stigmatization, which change the permeability of the skin, causing reddish, coloured tears, bleeding wounds, etc., are completely unknown, mainly because medical science has not been interested in these para-normal phenomena (see for a possible explanation also p. 152). It should be remembered, however, that it is the study of the para-normal phenomenon which often enables us to understand more fully the mechanism of the normal ones.

Fakir phenomena (sub 1 e): They comprise e.g., the phenomenon that certain people can have the chest completely pierced by a sharp object, without bleeding, so long as they concentrate on the experiment; as soon as their attention is distracted bleeding starts. A famous example in recent times is Mirin Dajo, described in the Dutch Journal of Parapsychology, November, 1946. Other examples are people who can walk barefooted over red, hot coal without burning their feet.

Medical science is usually not interested in the study of the physiological processes of these phenomena, which seem to be controlled by the mind of the fakir. This attitude is regrettable, as the solution of this problem might be the key to many unknown processes in the human body and in the brain of man.

Telepathy (sub 5): The study of this problem might have to be coordinated with the problems mentioned under 1 c. Also the methods

used by the *yogi* (i.e., people practising *yoga*) of India must be studied scientifically and modern applications of their methods might prove to be of great value for mental diseases. Scientists are often inclined to think of a yogi as a kind of magician or charlatan, but this is definitely incorrect. In one of the sacred books of India the *Bhagavad Gita* almost every chapter is devoted to some kind of "yoga" or method of "realizing the ultimate truth" or "attaining the highest wisdom". Different branches of yoga science are known, e.g.:

1. *Hatha yoga*, which teaches how to conquer physiological processes, such as hunger, thirst, sleep; how to overcome effects of cold and heat; how to cure a disease without using drugs, etc.
2. *Râja yoga* deals entirely with the mind and psychic power, its aim being the removal of all mental obstructions and substituting a perfectly controlled, healthy mind. Both the will-power and power of concentration are developed.

As with dowsing yoga has a great core of reality and it is this core which should be developed by unprejudiced physiologists and psychologists. The study of yoga and the studies mentioned under 1 might explain the basic mechanism of the process of thinking; it might reveal the existence of brain-waves, unknown at present, which could be responsible for telepathic phenomena.

Psychoscopy or psychometry: It assumes that every object connected to a human body is saturated with a "*psychoscopical emanation*"; this enables certain sensitive people to recount different details about the history of the original bearer of the object.

On p. 48 we discussed the existence of a *volatile aura* around living and non-living objects; on p. 303 and p. 359 we reviewed the reality of the "*shadow phenomenon*" during dowsing experiments as being different for male and female persons and seeming to be caused by an *electric aura* surrounding all living organisms; finally on p. 120 we mentioned the existence of a *radiation aura* caused by the infrared radiation of the human body. A careful study of experiments with trustworthy psychometrists might reveal the existence of other unknown auras or might show us that the three auras are sufficiently characteristic for each human being to enable a sensitive person to determine the character and other properties of the bearer from an object which for a long time was kept by that person in his neighbourhood. In this connection it is interesting to recall the incredible sensitivity of dogs who can recognize their master from a piece of rock, held only for a few seconds in his hands (see p. 104).

Kallipedic phenomena: They comprise those phenomena which should demonstrate the influence of the mind of the mother on the embryonic stages of a child. A great number of publications appeared on this subject (see Bibl. No. 1451a-1462a); an extensive bibliography was compiled by Dr Stokvis of Leiden University (Holland) in Bibl. No. 1459. At present the general medical opinion can be summarized as follows: all

reports on kallipedic phenomena are either untrustworthy or the reported phenomena are not due to the mental condition of the mother. ZORAB (Bibl. No. 1462a) rightly pointed out that kallipedy, if existing, is a very rarely occurring phenomenon, if the influence should be directly observable externally on the body of the child (e.g. as an undeveloped organ, blindness, etc.). However, the influence could also be registered internally and shows only after the child has grown up, in his mental reactions, etc. A superficial study of a few hundred cases is of little importance for the solution of this problem. As long as cases are known such as those reported by Dr A. J. FORMIJNE (Bibl. No. 1452), Dr C. H. MASTON (Bibl. No. 1455) a.o. the existence of kallipedic phenomena cannot be denied without positive evidence, the more so as kallipedy can be expected on theoretical grounds. The latter are:

1. *Discoveries of modern endocrinology:*

The growing embryo requires different substances from the mother which, during the first weeks are supplied through the permeable membranes of the *blastoderma* (the size of the foetus on the 12th day after fertilization of the egg is only 2 mm, after 6 weeks abt. 20 mm, after 8 weeks 4-5 cm). After development of the *placenta* and *funiculus umbilicalis* the food is mainly supplied along blood vessels in these organs.

a. It is well known that cellgrowth is regulated by the presence of certain growing agents (see p. 270).

b. GAILLARD (Bibl. No. 1452a) could prove, with tissue studies in vitro, that development of cellgrowth into different human tissues (bonetissue, muscle-tissue, etc.) is regulated by special hormones secreted by the mother and which vary in composition during different stages of development.

c. MATTILL, CONKLIN and EVANS found that *vitamin E*, which occurs in cereals, lettuce, bananas, milk, eggs and muscles, has great influence on reproductive functions. Vitamin E deficiency in female rats leads to interference with the nutrition of the foetus, so that it atrophies and is absorbed. In male animals it leads to incurable atrophy of the germinal epithelium of the testes.

d. Studies of ALLEN, DOISY a.o. have shown the influence of *ovarian hormones* in the follicular fluids on the development of the embryo. One of these hormones is *progesterone* ($C_{21}H_{30}O_2$), which is able to prevent abortion; in the guinea pig it serves as a stimulus for the production of the maternal part of the placenta, etc. These hormones in the mother also influence her physiological functions (see also p. 118).

e. CROWE, CUSHING and HOMANS discovered in 1910 the great influence of the *pituitary gland* (hypophysis) on the reproductive system. This gland is connected by nerve fibres (abt. 100,000) to the *hypothalamus*, a part of the brain-stem that lies at the base of the diencephalon, below the thalamus (see p. 131). Physiological evidence has shown that

many sensori stimuli are capable of influencing the neural mechanism in the hypothalamus. The hypothalamus discharges electric impulses that cause or modify reactions in a large part of the visceral and skeletal effectors of the body. These facts indicate that the hypothalamus has abundant connections with other parts of the central nervous system and that mental processes in the cerebral cortex can influence the function of the hypothalamus and pituitary gland; the latter exert its influence through production of *gonadotropic hormones*. Similar complicated relationships are known between the function of the cerebral cortex and the function of the endocrine glands such as the *adrenal gland*, *thyroid gland*, etc.

The extraordinary power of mental forces, which is demonstrated in the stigmatization and fakir phenomena and the capacity to change fundamentally the hormone supply in the mother and therefore also in the foetus, makes it possible that external causes that are able to create a mental shock would be reflected in sudden changes in hormonic effects.

In this connection it is interesting to learn that for centuries diviners used to prophecy the sex of an expected child by studying the physionomy and the craving of pregnant mothers for special foodstuffs. The latter method seems to have been applied with great success recently by Dr Ph. C. VISSER, Dutch minister at Pretoria (S. Africa). Diviners used to say that a female embryo has greater effect on the general health and mental condition of the expectant mother than a male embryo, which would show up particularly in the physionomy of the mother (tired expression, rings under the eyes, apathy, etc., in case of a female child). In view of the latest scientific discoveries this observation might be partly or wholly true. The hormone supply of the child is different in the case of a male or female embryo and the distribution of hormones and vitamins in the mother by the action of the embryo itself must be different too. As an expectant mother and female foetus probably require the same kind of hormones, the female embryo could be more harmful to the mother than a male embryo. Of course the processes are not as simple as this, but it shows how the observations of diviners, always ridiculed by scientists, might prove to be correct, as with the discovery of checking agents by ALBERTUS MAGNUS in 1300, but only recognized by scientists after recent chemical studies in the 20th century.

2. *Surface potential measurements of* H. S. BURR:

On p. 198-199 we discussed the experiments of BURR and NORTHROP. Their studies have shown that there is a relatively steady rate of electric voltage difference between any two points of a living body and a pronounced polarity between head and tail. These standing potentials define an electro-dynamic field in the living organism, which fundamental pattern determines the organization and development of the growing

embryo. The experiments of Burr with a frog's egg (see p. 15 and 198, Bibl. No. 30) are an excellent example of this phenomenon. As mental processes regulate our skin-potentials and the electric fields in the internal parts of the body, it seems logical to assume an inductive influence of the mother on the growing embryo as an indirect result of important mental processes. The importance of the electric field of the mother is also indicated by the observation of radiesthesists and dowsers of a neutral zone above the central part of the human body (see p. 369).
During pregnancy a pendulum rotates above this place and the rod turns; the turning seems to be different for male and female embryos (as far as this observation can be trusted statistically).

3. *Discovery of the rhesus factor by* K. Landsteiner *and* A. S. Wiener (an excellent summary of this problem has been given in Bibl. No. 1451a):

After the discovery of the A (resp. A1 and A2), B and O *blood groups* (about 1900) by Landsteiner and the assumption that the agglutination of the erythrocytes is created by the presence of two substances, the *agglutinogenes* (substance that can agglutinize) and *agglutinines* (substances causing the agglutination of the agglutinogenes), in about 1928 Landsteiner and Levine discovered the M, N and P *blood groups*. It has been found:

a. that the blood groups (i.e., the agglutinogenes) are hereditary and follow the laws of Mendel;

b. that in certain races certain blood groups dominate, e.g., in pure American Indians the O group, in Europe the A group, in India the B group;

c. that the agglutinogenes have an *antigenous* activity, i.e., injection of human A erythrocytes, e.g., in rabbits creates anti-A agglutinines; anti-M agglutinine has been rarely found, anti-N and P agglutinine never.

In about 1940 Landsteiner and Wiener discovered the *rhesus agglutinogene*. After injection of a rabbit with erythrocytes of a monkey *Macacus rhesus* and after absorbing all known A, B, O and M agglutinines, a serum was obtained that caused the agglutination of erythrocytes of man in 39 cases out of 45 experiments. It was assumed that this serum contained an unknown agglutinine and the human blood an unknown agglutinogene, the Rhesus agglutinogene. People possessing this factor were called *rhesus positive*, those without it *rhesus negative*.

The studies of A. Dienst (in 1905) on the cause of eclampsy during pregnancy, of R. R. Darrow (in 1938) on the cause of erythroblastosis foetalis (i.e., blood destruction in the new-born child), of P. Levine and M. Stetson (in 1939) on the cause of agglutination of blood after transfusion, even if donor and patient belong to the same blood group, extended by the studies of A. S. Wiener and H. R. Peters in 1940, finally led in 1940 to the *rhesus-iso-immunization*

theory of Levine-Stetson, Katzin, Burnham and Vogel. This theory assumes that, because of the difference in composition and structure of the hemoglobin (see p. 78) of the foetus and of the mother, diffusion of the antigens takes place; this is created by the Rhesus agglutinogene of the foetus, through the placenta into the blood stream of the mother. These antigenes immunize the mother but develop agglutinines (Rhesus) which, after re-entering the blood circulation of the child, cause agglutination, haemolysis and damage of internal organs. If the foetus has inherited the antigen of the father and it is missing originally in the mother, transfusion of the blood of the father into that of the pregnant mother will cause agglutination of the erythrocytes of the father in the blood of the mother.

Wiener and Peters found that 85% of white people are Rh-positive, 15% negative. Very few Chinese and Indians are Rh-negative; for negroes the value Rh = 9%, for American Indian Rh = 0.8 % and for Japanese Rh = 2 %.

If both father and mother are rhesus positive or negative, nothing happens, but if the mother is Rh negative and the father positive a dangerous situation may arise.

Later studies in 1944 by Mac Call, Race and Taylor revealed 6 subgroups of the rhesus factor: Rh_1, Rh_2, Rh_0, rh, Rh′ and Rh″; Rh_y and Rh_z were discovered later.

This brief summary of the Rhesus phenomenon indicates the complicated interaction of the blood components of the mother and child which could create serious damage to the growing foetus and the mother. As the composition and physical properties of the blood of the mother can be influenced by mental processes, a certain influence of particular mental conditions of the mother on the embryo can hardly be denied.

Previous observations have demonstrated that each of the abovementioned ten primary problems, to be solved by a laboratory for psychical physics, and which were formulated for the first time by diviners and para-psychologists, is based on scientific observations that require only coordinative work of a great number of specialists in order to find the solution. This review shows also that psychic and physical problems are so much interwoven that they cannot be separated, although vitalists are always inclined to do so.

Before we close this chapter on psychical physics a few words should be said on a number of physical experiments made on problems related to the divining phenomena and which should be repeated by a central laboratory of psychical physics. These experiments are:

1. Experiments of Crile (Bibl. No. 1434a);
2. Experiments of Watters (Bibl. No. 1448a and 1449);
3. Experiments of Osty and Price (Bibl. No. 1435, 1436, 1442, 1444);
4. Experiments of Reich on orgone energy (Bibl. No. 1463-1472).

Expirements of Crile:

In about 1930 a series of experiments was carried out by Crile, the results of which can be summarized as follows:

1. Normal animals were killed and shortly afterwards the brains removed. The lipoids, proteins and inorganic salts were extracted. By mixing these substances under certain conditions in certain ratios cellular bodies appeared that resembled protozoa. Crile called these bodies *autosynthetic cells*.
2. The autosynthetic cells are able to absorb oxygen and extrude CO_2 in a manner similar to an ordinary metabolic process.
3. They could be kept "alive", i.e., growing, etc., by adding continuously sterile protein solutions.
4. External forces (heat, X-rays, etc.), which can destroy ordinary cells, also damage the autosynthetic cells.
5. The shape of the autosynthetic cells (globular forms, spirals, etc.) was dependent upon the pH of the solution.
6. Autosynthetic cells also originated if proteins from other tissues were used.
7. If brains of animals were used, which died of disease or exhaustion or if the extracts were kept too long, the extracts no longer possessed the capacity of creating autosynthetic cells.
8. All animals and plants possess electric surface potentials which fall off to zero as soon as the organism dies; for a short time the organism regains its surface potential but this is followed by a final permanent drop to zero.

We are not sufficiently well informed on all the details of Crile's experiments to be able to judge their value. They were carried out primarily to study the physical nature of death. However, they sound interesting enough to be tested carefully by a group of physiologists.

Experiments of R. A. Watters:

Dr Watters, Director of the Dr William Bernard Johnston Foundation for Psychological Research (Reno, Nevada, U.S.A.) is a vitalist and assumes that the human soul occurs in the intra-atomic space between the atoms of the human cells, a hypothesis based on the *theory of* Gaskell, published in her book "What is Life" (Charles C. Thomas Publ. Co., Springfield, Ill., U.S.A.). According to Gaskell life is an intra-atomic substance that cannot unite with matter. Death means a separation of both systems. In order to study the truth of this hypothesis Watters studied the physical processes of dying animals in a *Wilson expansion chamber*, used for the study of radioactive radiation. A large grasshopper was placed in the chamber and was slowly killed with ether. The moment the animal gave the impression of being dead, the expansion of the water vapour occurred and a photograph was taken of the condensation figure. According to Watters, in all cases where the animal remained dead,

even after 8 hours' observation, a shadow phenomenon appeared in the expansion chamber roughly coinciding with the shape of the animal. If the photograph was taken at a moment that the observer assumed the animal to be dead, but the animal revived later on, no condensation figures were obtained. Similar experiments were carried out with frogs and white mice. In only three cases (out of 40 experiments) were positive results obtained with mice. This was ascribed by WATTERS to the difficulty of taking a photograph exactly at the moment of death.

Whether these condensation figures are due only to a sudden change

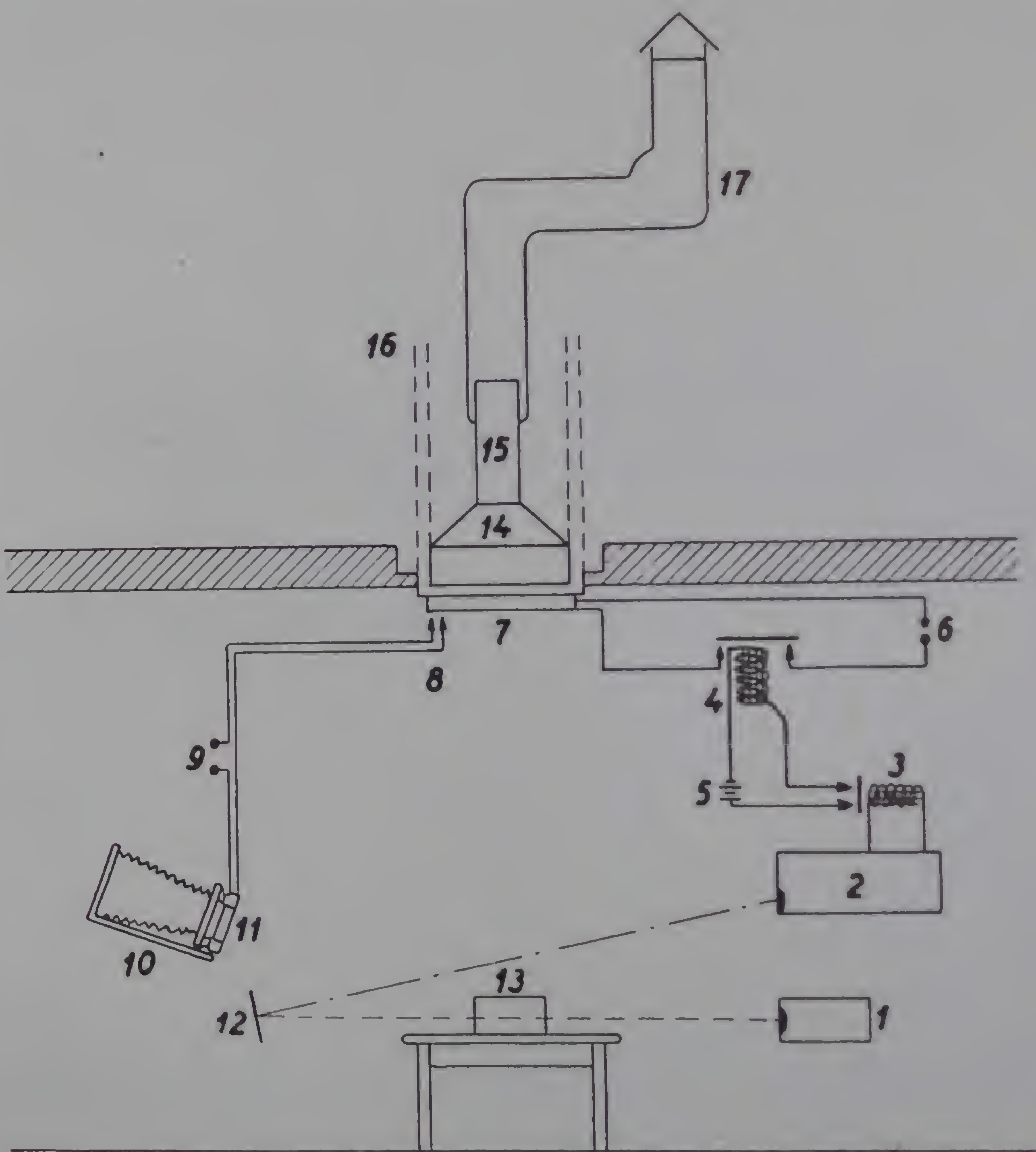

Fig. 151: (Bibl. No. 1435, p. 153) Apparatus used by OSTY (Bibl. No. 1442) for studying telekinetic and teleplastic phenomena: 1) source of infra-red rays; 2) photoelectric cell with amplifier; 3) and 4) electro-magnetic switches; 5) accumulator of 4 V; 6) circuit of alternating current of 110 V; 7) apparatus used for a complete black-out; 8) electric contact brought into action by opening No. 7; 9) circuit of alternating current of 110 V; 10) photographic apparatus with quartz lenses; 11) key for closing lens; 12) mirror; 13) test object; 14) a set holding 20 mercury lamps; 15) telescope chimney; 16) cables for raising No. 14; 17) ventilator.

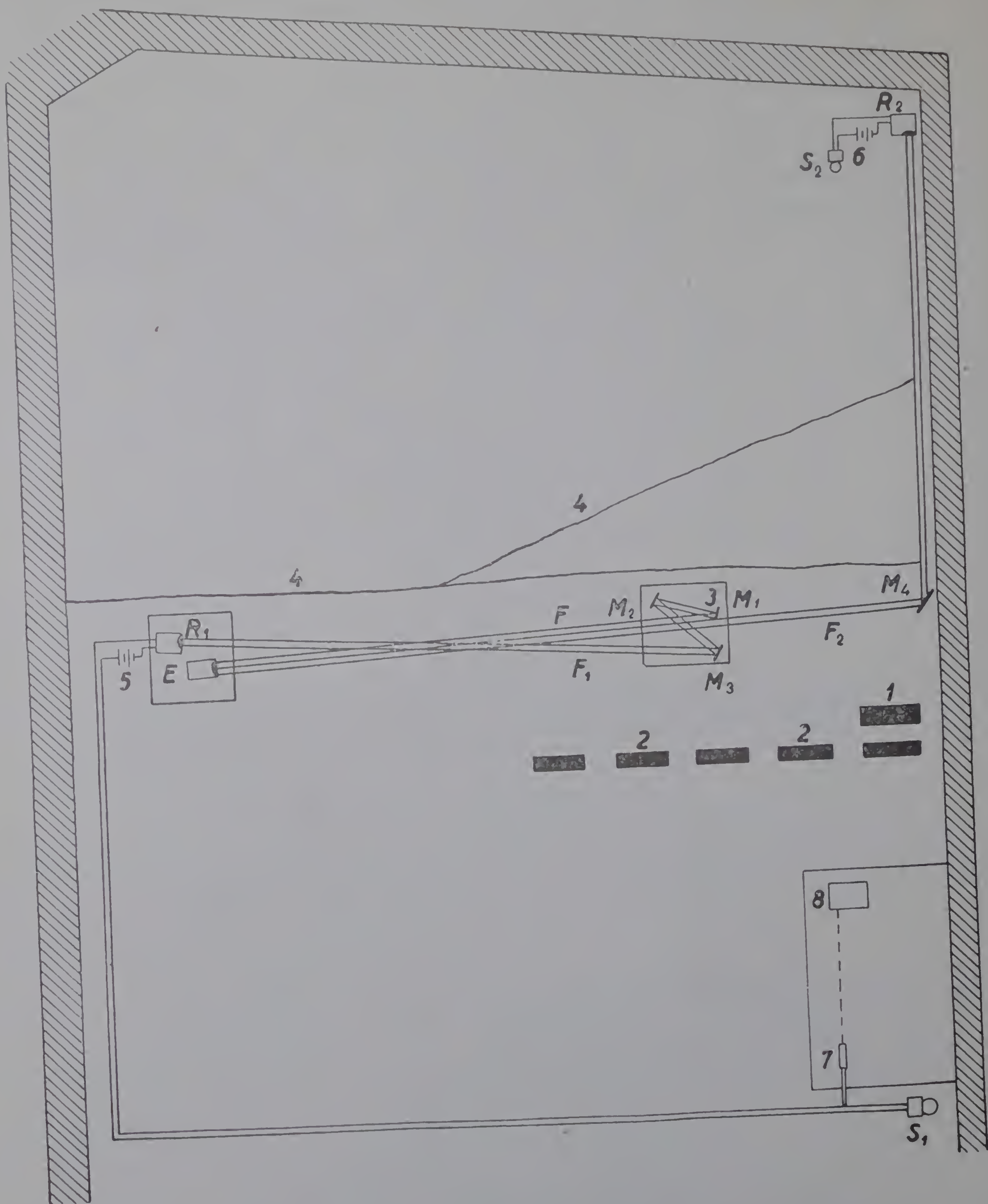

Fig. 152: (Bibl. No. 1435, p. 50) Apparatus for studying telekinetic phenomena: 1) medium; 2) assistants; 3) table; 4) curtain; 5) and 6) 4-volt accumulator; 7) lamp; 8) photographic apparatus for registering; E) source of infra-red light; F) bundle of infra-red rays; M_1, M_2, M_3, M_4 mirrors; F_1) half of bundle of infra-red rays reflected along the object; R_1) photo-electric cell, amplifier and switch; S_1) bell; F_2) half of bundle of rays directed to M_4; R_2) photo-electric cell and switch; S_2) bell.

in temperature or to the change in electric skin potentials of the dying animals, it is difficult to say. The volatile aura (see p. 48) might be responsible for the phenomenon, which we consider of sufficient interest to recommend a further study. However, we disagree with Dr WATTERS that these experiments indicate a condensation figure of the animal soul, which according to WATTERS and GASKELL should be fundamentally different from matter.

Experiments of Dr E. OSTY and engineer M. OSTY:

In about 1930 a series of experiments was carried out by Dr OSTY and his son in the Laboratory of Psychical Research in Paris with the

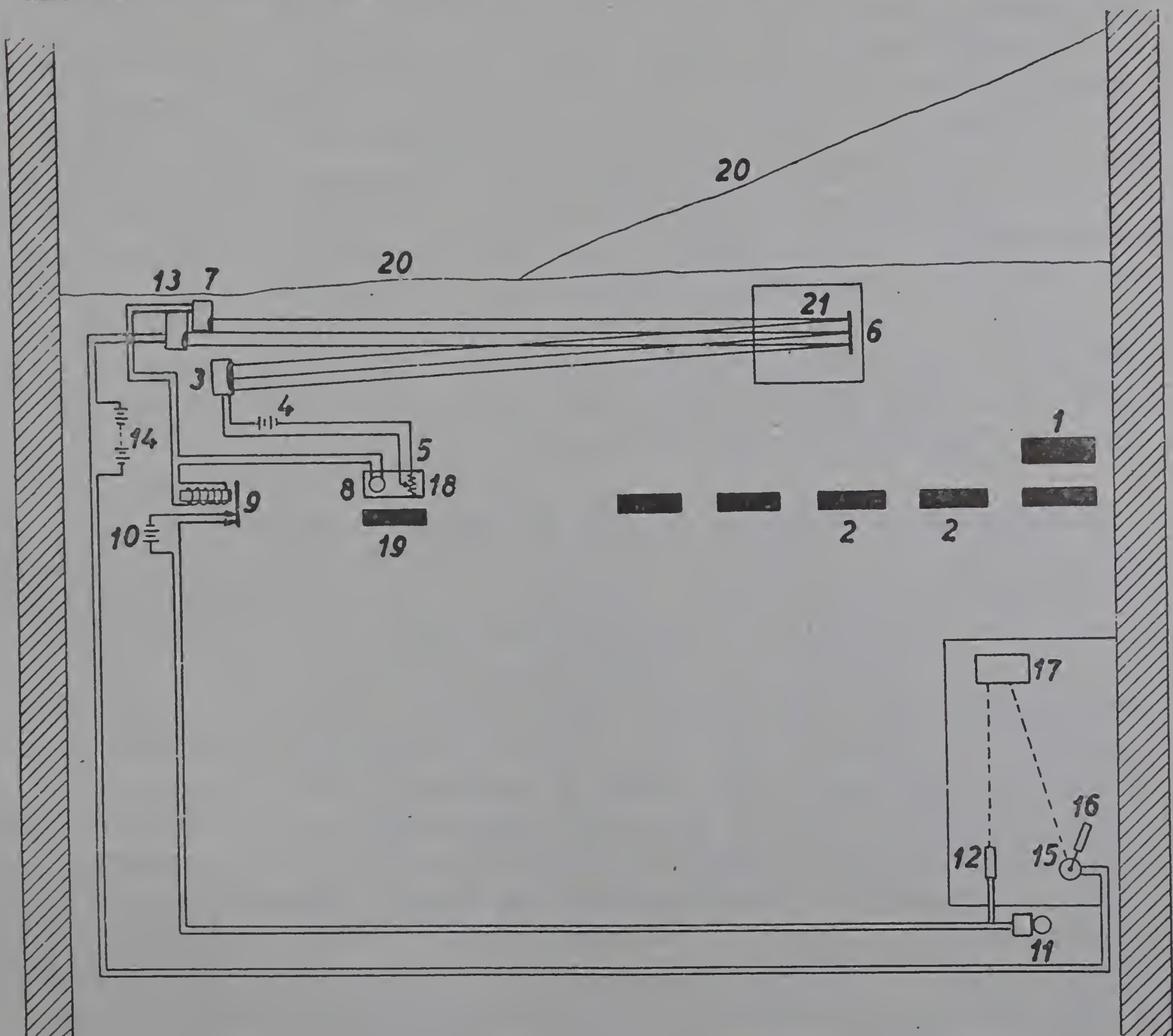

Fig. 153: (Bibl. No. 1435, p. 52) Apparatus for studying telekinetic phenomena: 1) medium; 2) assistants; 3) source of infra-red rays (E); 4 and 10) 4-volt accumulators; 5) resistance regulating intensity of infra-red bundle; 6) two mirrors placed next to each other; 7) photo-electric cell with amplifier; 8) milliampère meter; 9) switch; 11) bell; 12) lamp; 13) photo-electric cell; 14) 40-volt accumulator; 15) ballistic galvanometer; 16) lamp galvanometer; 17) apparatus for registering; 18) box containing switch-board and resistance regulating a red lamp used for general illumination; 19) person leading the experiments; 20) curtain; 21) table.

medium RUDI SCHNEIDER, in order to study *telekinetic phenomena*, i.e., movements of light objects at a certain distance of a medium without any simple mechanical cause. In order to prevent any magical trick a complicated apparatus was constructed using infrared rays. The figs 151-153 give some idea of the precautions taken by OSTY and his assistants. It was found that:

a. the medium could interrupt the bundle of infrared rays at a distance;
b. the interruption took place at moments predicted by the medium;
c. the white magnesium light, used during the photographic registration, seems to disturb this telekinetic effect;
d. oscillatory interruptions occurred which coincided with the respiration frequency.

Whether these experiments, which were partly repeated by H. PRICE in London, really indicate fundamentally new phenomena, or whether they are only a special example of the experiments of HEYDWEILLER and SCHUMANN (see p. 178), of the fluctuating infrared radiation of the human body (see p. 120) or of the fluctuating volatile aura (see p. 48) it is difficult to say, the more so, as it is very exceptional that people can be found who posses these para-normal capacities. As soon as a similar case is again reported, it would be the duty of a laboratory of Psychical physics to extend the studies of OSTY and to consider the above-mentioned explanations which were apparently not taken into consideration by OSTY and his son.

Experiments of Dr. W. REICH on orgone energy:

Dr REICH is a pupil of Prof. FREUD, who left Austria and Germany during the Hitler regime and established, first in Sweden and later in the U.S.A., an *Institute for Sex-Economy* and *Orgone Research*. This institute regularly publishes an international journal of which a few interesting articles were compiled in Bibl. No. 1463-1472. REICH assumes that besides physical energy the world is permeated with a non-material *orgone energy*, the source of sexual energy and of the fundamental phenomena of life. Although we do not agree with his interpretations, his observations are interesting and are worthy of repetition. REICH discovered that if water is filtered through ordinary garden soil and the yellowish fluid is kept in bottles in a frozen state, after thawing dense flakes appear which, at a magnification of 3,000, show pulsating phenomena which he compared with living cells. These pulsating bodies were called *bions*. Freezing of ordinary spring water or distilled water fails to produce such flakes. REICH found that these *bion fluids* show fluorescence phenomena. The fluoro-photometric value of the fluids were used as indicator of the *orgonotic potency* of the fluid. Microscopic examination of the flakes showed two basic types:

a. smooth, plasmatic, but well-defined forms in which dark granules are dispersed;

b. heaps of bionous vesicles.

Preparations kept under sterile conditions showed an increase in flakes after a few days and a much greater increase after 2-3 weeks. They seem to grow through the addition of substance and increase in number by division.

After evaporation of bion water a yellowish powder of brownish crystals remains, called *orgontin*, which cannot be dissolved in bion water. These crystals show only manifestations of growth, multiplication, etc.

Injection of bion water of high orgonotic potency into living organisms, plants and animals, results in vigorous vagotonic reactions which, according to REICH, have a life-prolonging effect.

It would require too much space to discuss all the other experiments of REICH that indicate the presence of pulsating orgone energy in all matter, both living and non-living. His experiments are extremely interesting but his interpretations seem to be definitely incorrect. For example, the experiment with bion water: although we must confess that we have not yet repeated this experiment, his observations correspond perfectly to the phenomenon one would expect, i.e., the whole process seems to be due to the development of fluid organic crystals (see p. 9 and 29), which he called *bions*.

Experiments with pendulums, in order to demonstrate the orgonotic pulsation in the atmosphere (only observable when the relative humidity is less than 70%), are also explainable with the ordinary electric phenomena, discussed in chapter I, part III.

However, the application of solutions of fluid organic crystals and of specially crystallized drugs in general, might open up a new field of medical research.

The experiments of REICH and others, discussed in chapter III, almost without exception contain an interesting scientific core that should be analysed by the laboratories of psychical physics. It is a sign of narrow-mindedness that these experiments are often rejected by scientists because the explanation sounds unscientific and might be completely wrong. It is not the interpretation which is important, but the facts. Interpretations given even by the most prominent scientists often had to be changed during the history of mankind, but the facts remain. Most scientists of the 20th century seem to lack the courage and the romantic feeling to tackle problems which at first sight seem incredible and without any practical prospects. It is the unconventional scientist who enables the work to progress more rapidly.

We have reached the end of chapter III and of this publication on the science of divining phenomena. We have endeavoured to demonstrate that an enormous number of fundamentally unknown phenomena

occurs in the living world which should be united into an independent science, the *science of divining phenomena*. This should be the sphere of interest of the *Laboratories of Psychical Physics* all over the world. It requires coordinative work of a great number of scientists who would combine great intelligence with a highly critical mind and an unprejudiced conception. For the first time in the history of mankind we would have at our disposal the gigantic strength of science to solve these most fundamental philosophical problems of life. Let us prove worthy of the task that lies ahead.

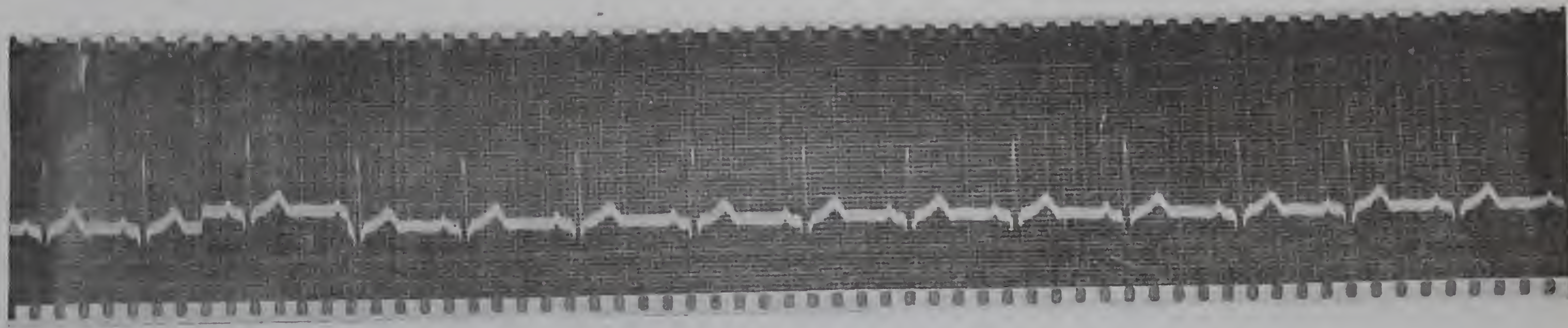

Fig. 101: Ordinary electro-cardiogram with both electrodes attached to left and right-hand pulse respectively (lead no. I). Trial person (male) sits quietly in a chair, both arms at ease.

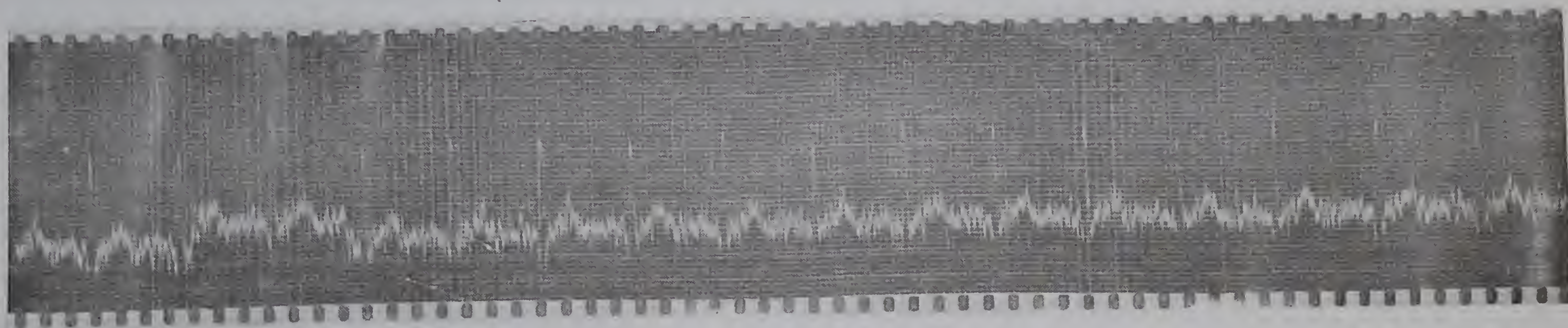

Fig. 102: Electro-cardiogram measured of same person as fig. 101 sitting in a chair, but both electrodes attached as in fig. 100, creating a circuit through the body, the rod and the string galvanometer. Person is holding a steel divining rod (see fig. 86) in two loose insulated grips. The Piper rhythm (see p. 161) is superimposed on the P.Q.R.S.T. curve (see fig. 16). Diagram is the same as in fig. 101 if the trial person strains his arm muscles. High peaks at regular intervals represent the R-top.

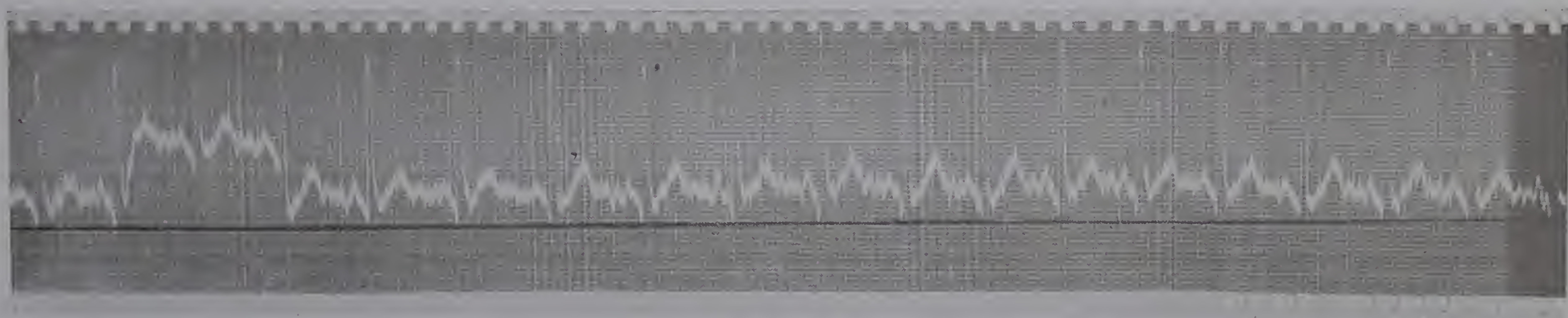

Fig. 103: Standing quietly outside the zone of disturbance in the room of fig. 99 (near the door to small room), electrodes attached as in fig. 100, divining rod held in loose insulated grips. Diagram represents a photographic picture of the heart-action currents for a period of 12 seconds. Sudden rise of curve near the left end of the cardiogram is due to an automatic registration, which enables the observer to estimate the electric potentials in the wires and on the skin. In the original electro-cardiogram (of 25 cm length) a vertical excursion of 1 cm represents 1 m.V. Note that in this figure all Q-peaks are situated sharply on a straight line.

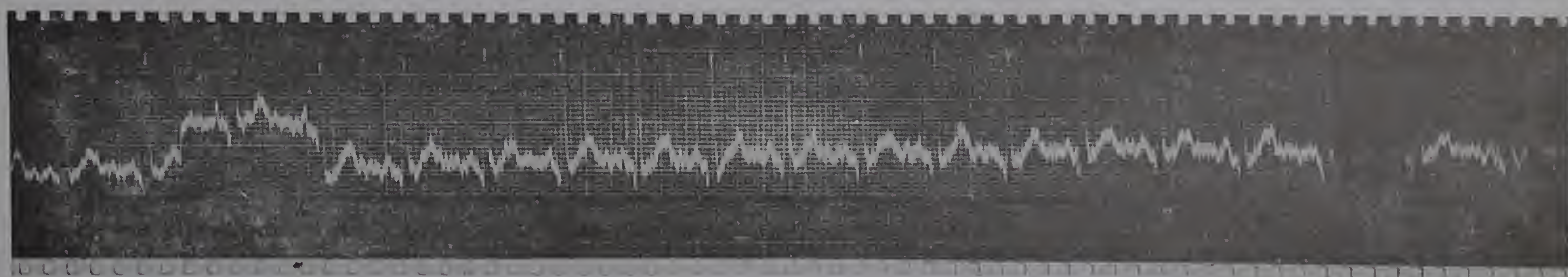

Fig. 104: Same experiment as in fig. 103, but standing in the zone of disturbance of the room of fig. 99. Contrary to fig. 103 Q-peaks rise gradually towards the right end of the electro-cardiogram due to a slow change in the electric potential of the skin.

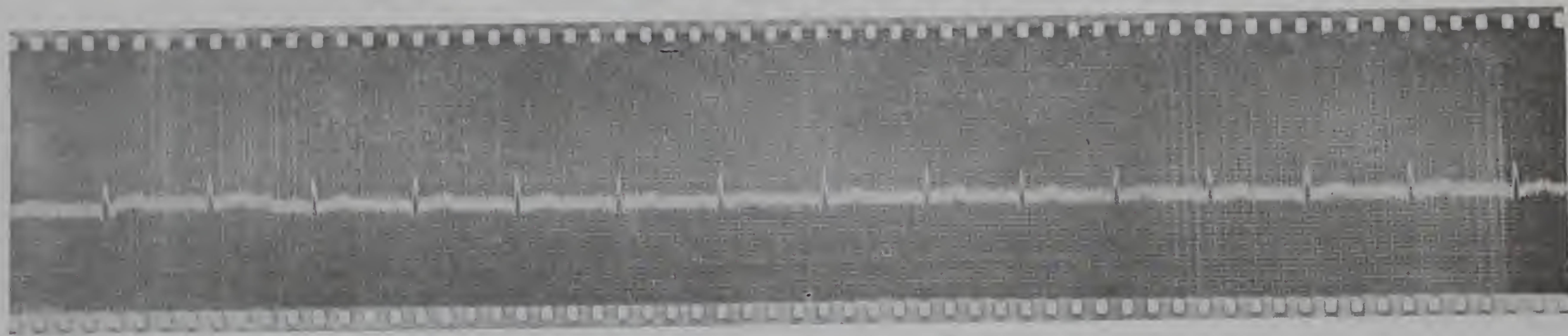

Fig. 105: Same experiment as in fig. 103 (on 30.9.1946), standing outside the zone of disturbance, rod with loose insulated grips. String was more strained than in fig. 103 (1 mm in vertical direction represents abt. 1 mV). High peaks represent R-top (compare fig. 102).

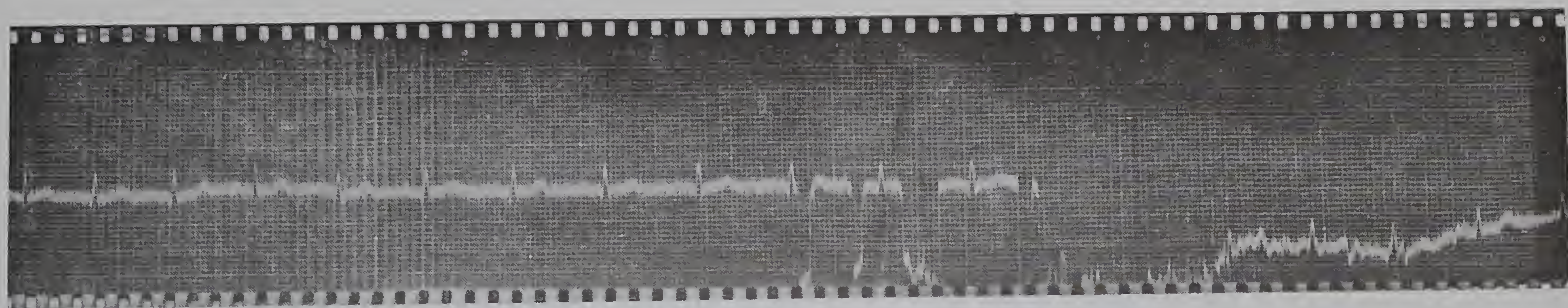

Fig. 106: Male person (Mr T., sensitive to dowsing), walking slowly, immediately after experiment of fig. 105, from same position outside the zone of disturbance into the zone of disturbance, perpendicular (i.e., along section A—A in fig. 99) to the longest axis (i.e., line B—B) of this zone; rod with loose insulated grips (in order to prevent turning of the rod in the zone of disturbance); electrodes connected as in fig. 100. After entering the zone of disturbance irregular peaks occur and the whole diagram shows a considerable excursion downwards, which equals a change in electric potential of 20 mV and more. After the zone is passed the curve rises again (right side of cardiogram) and finally returns to the initial level. Left part of cardiogram indicates that movement as such does not create excursions of the string.

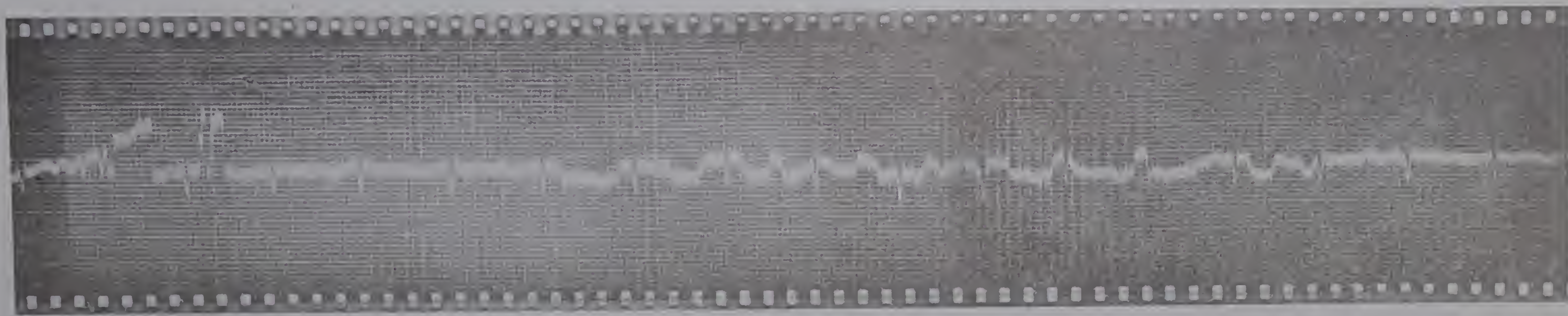

Fig. 107: Same experiment as in fig. 106 (made immediately afterwards) but walking parallel to the longest axis (line B—B in fig. 99) of the zone of disturbance (arms still perpendicular to the axis). Movement along the line B—B took place toward the wall.

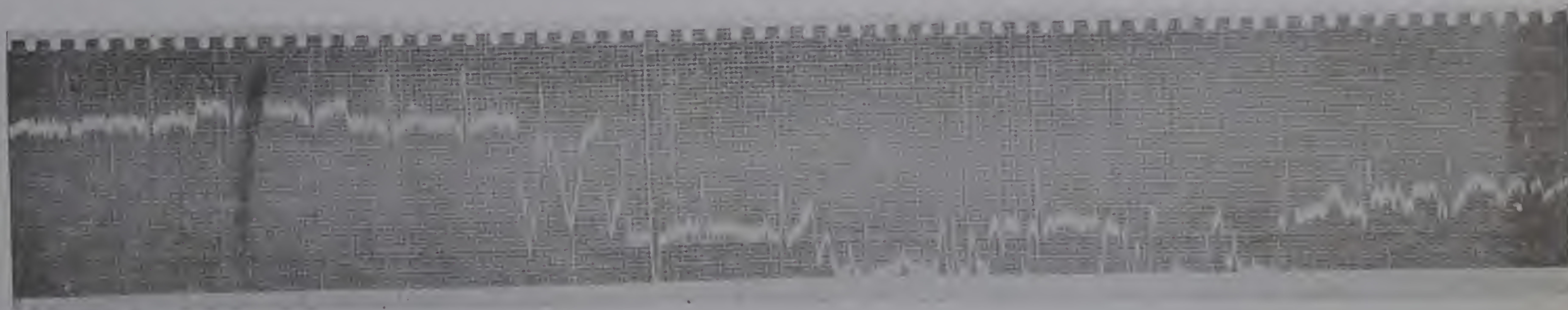

Fig. 108: Experiment of fig. 106 repeated on October 7th, 1946, with a less strained (more sensitive) string.

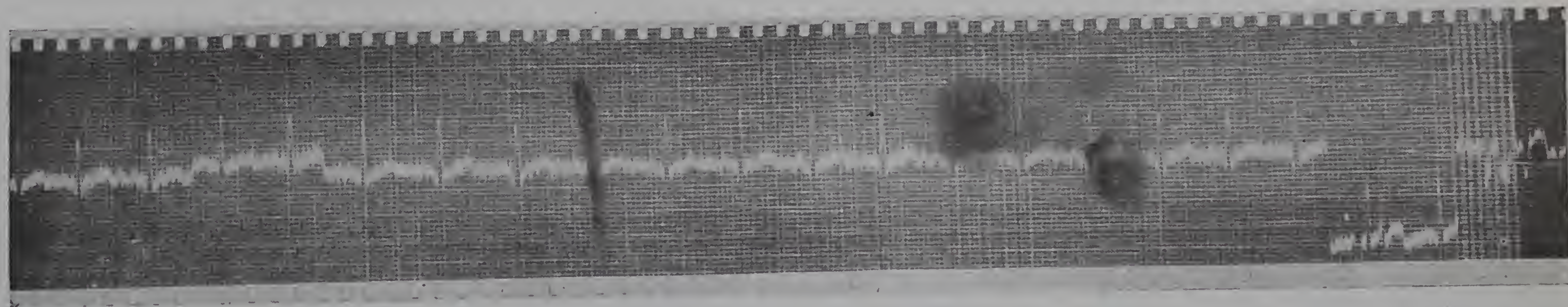

Fig. 109: Experiment of fig. 107 repeated on October 7th, 1946 immediately after experiment of fig. 108.

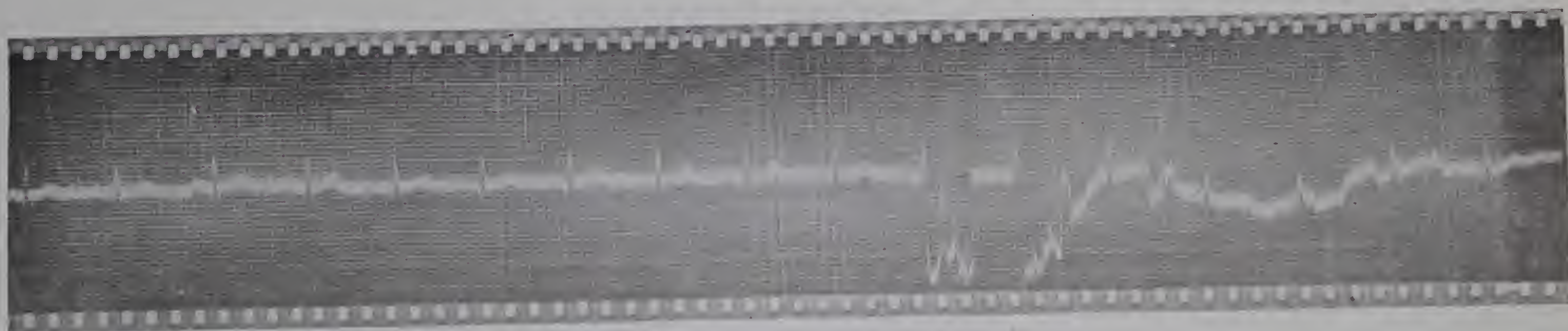

Fig. 110: On September 30th, 1946 experiment of fig. 106 repeated with rod and insulated grips, electrodes attached to both pulses. Similar excursions of string were observed.

Fig. 111: Experiment of fig. 107 repeated with rod and insulated grips (immediately after experiment of fig. 110), electrodes attached to both pulses.

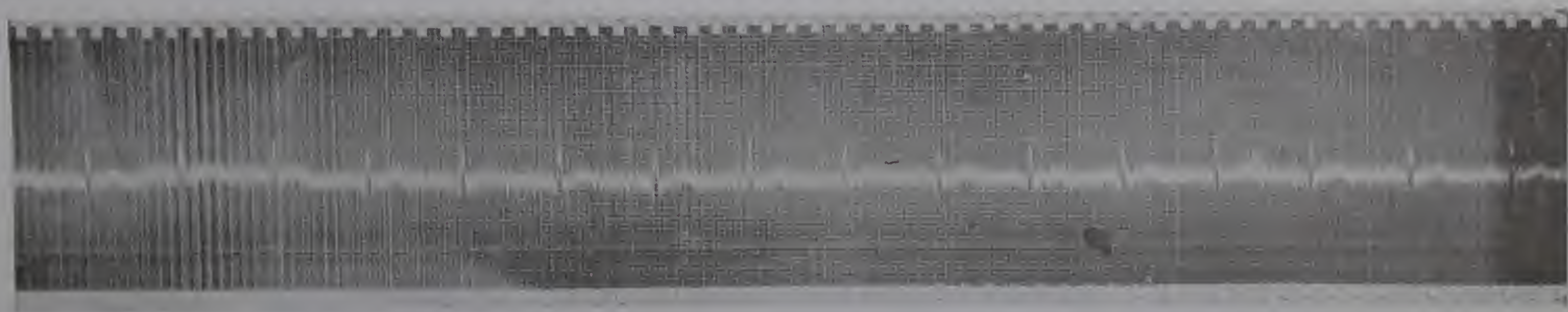

Fig. 112: Experiment of fig. 105 repeated (on September 30th, 1946) without divining rod, both electrodes directly connected with left and right-hand pulse respectively, arm muscles considerably strained.

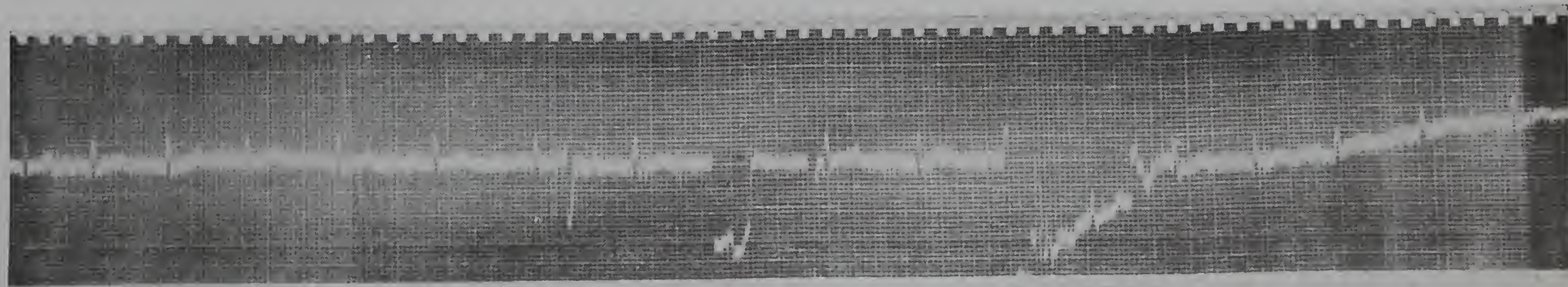

Fig. 113: Experiment of fig. 106 repeated (on September 30th, 1946) without a divining rod (immediately after experiment of fig. 112). Both electrodes connected directly with left and right-hand pulse respectively. Similar excursions of string occurred as in experiment of fig. 106 and 110, indicating that movements in dowsing zone, followed by changes in skin potential, are independent of the presence of a divining rod, the rod being merely an indicator for muscular contraction.

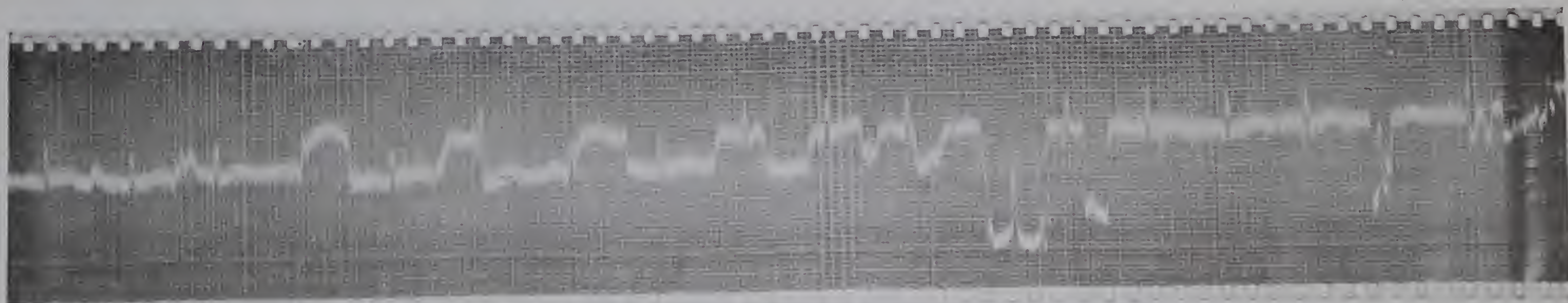

Fig. 114: Experiment of fig. 107 repeated without a divining rod, immediately after experiment of fig. 113. Both electrodes connected directly to left and right-hand pulse.

Fig. 115: Experiment of fig. 113 repeated on October 7th, 1946 with a female person (Mrs de G.), non-sensitive to dowsing. The cardiogram curve shows a similar subsidence in the dowsing zone as fig. 113, only the subsidence takes place more gradually and the change in skin potential is less than 20 mV.

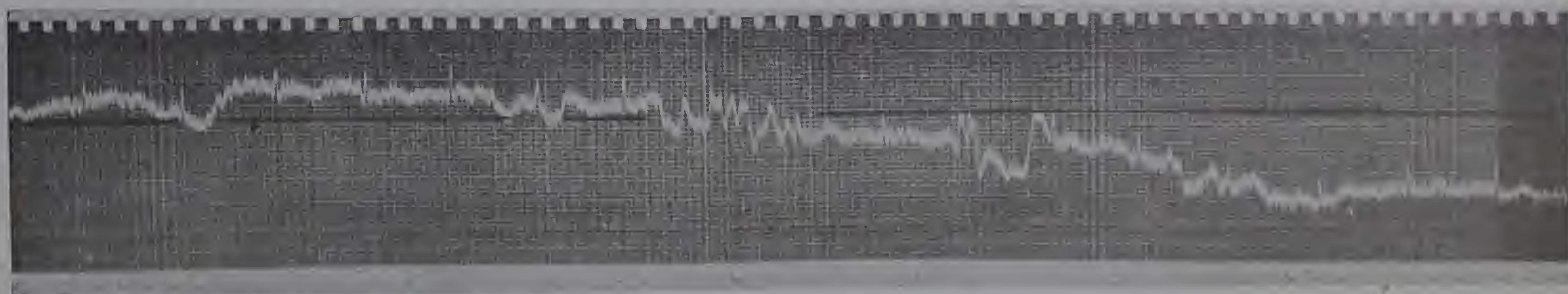

Fig. 116: Experiment of fig. 106 repeated on October 7th, 1946, with same female as in experiment of fig. 115. Subsiding curve is less regular than the curve obtained without a divining rod (fig. 115).

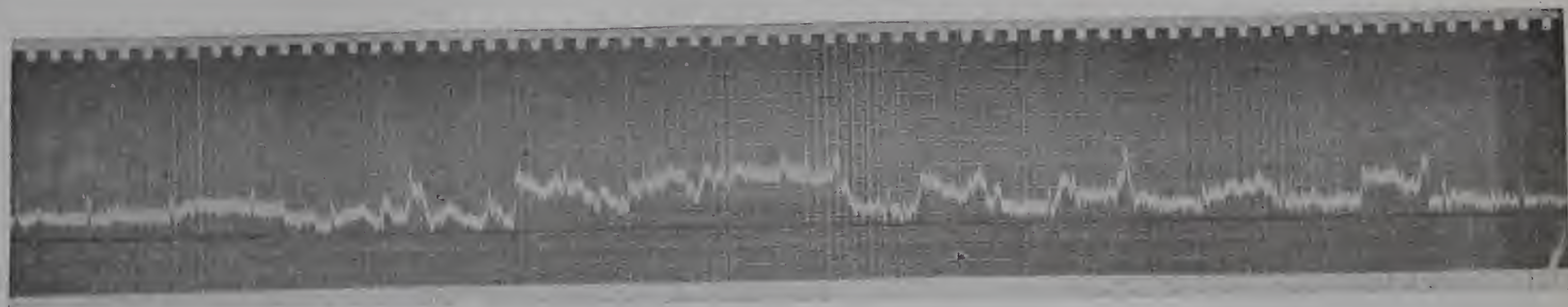

Fig. 117: Experiment of fig. 107 repeated on October 7th, 1946 with same female as experiment of fig. 115.

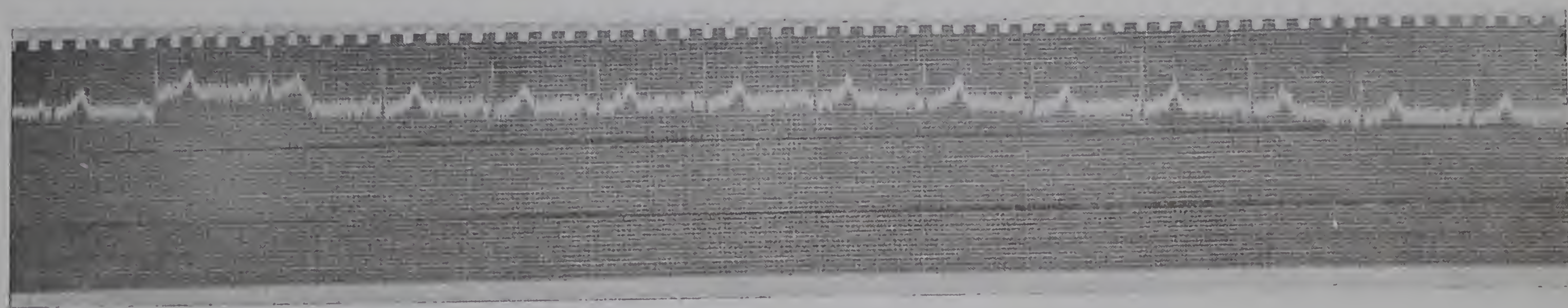

Fig. 118: Experiment of fig. 113 repeated on October 14th, 1946 with another female (Mrs de S.), non-sensitive to dowsing. Person walked very slowly through the zone of disturbance and after 24 seconds reached the end of the zone. Fig. 118 represents first 12 seconds of the recorded cardiogram (following 12 seconds see fig. 119).

Fig. 119: Continuation of diagram of fig. 118.

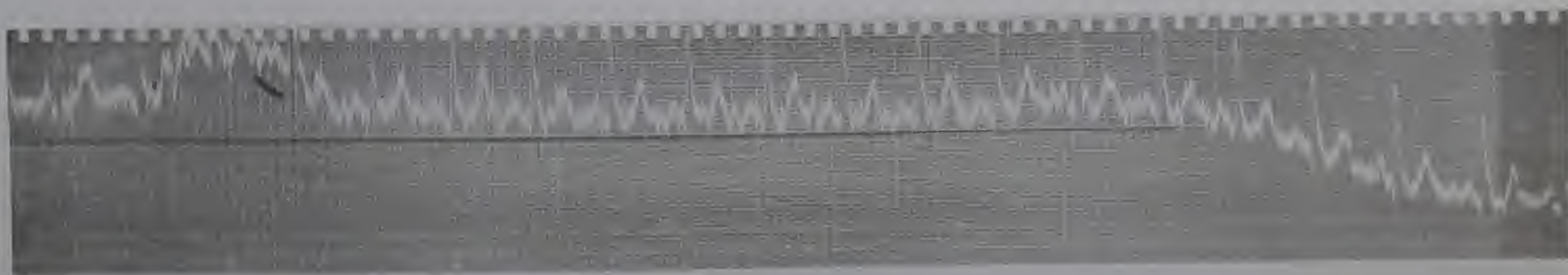

Fig. 120: Experiment of fig. 113 repeated on October 28th, 1946 with another female (Miss B.), non-sensitive to dowsing. The curve subsided slowly at the end of the zone of disturbance and returned slowly to the initial level after the person left the zone of disturbance.

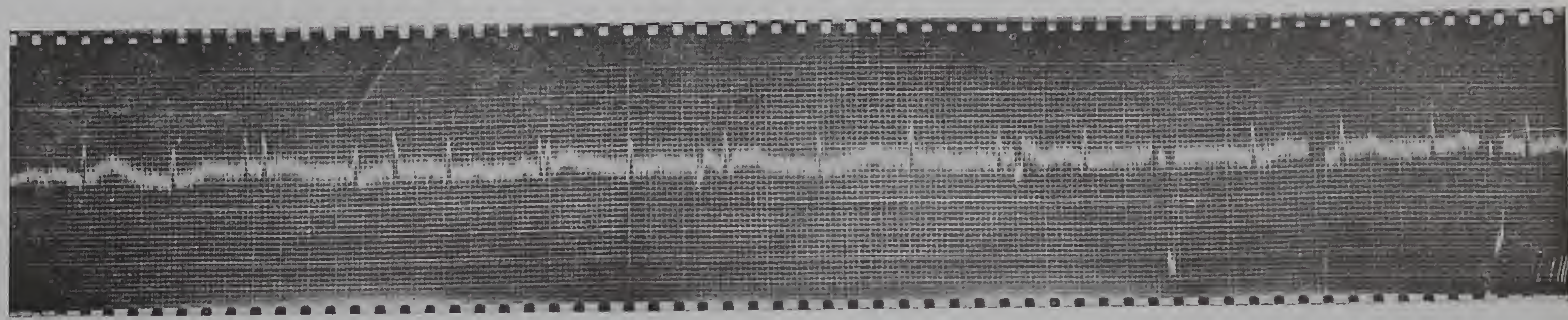

Fig. 121: Moving along a line X outside a zone of disturbance, in the small room annex to the large room of experiment of figs. 106-120 (see fig. 99). Rod, electrodes and dowser similar to experiment of fig. 106. Arms perpendicular to the line of movement. Date of experiment: September 30th, 1946. Note one small peak near the wall of the room at right side of cardiogram.

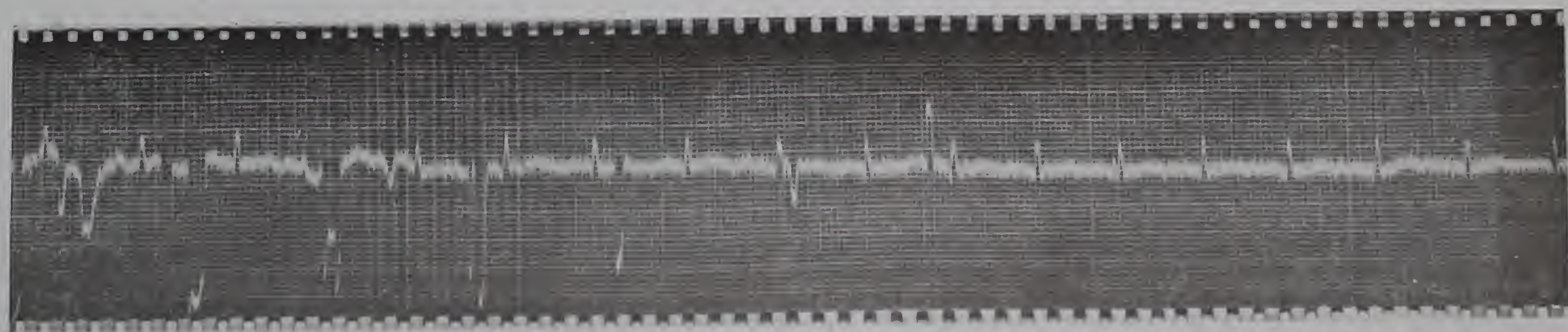

Fig. 122: Same experiment as fig. 121, but a small wooden rolling table with steel supports was placed on the line along which the dowser was moving. Presence of table showed up as four small peaks at left side of cardiogram (experiment immediately after experiment of fig. 121).

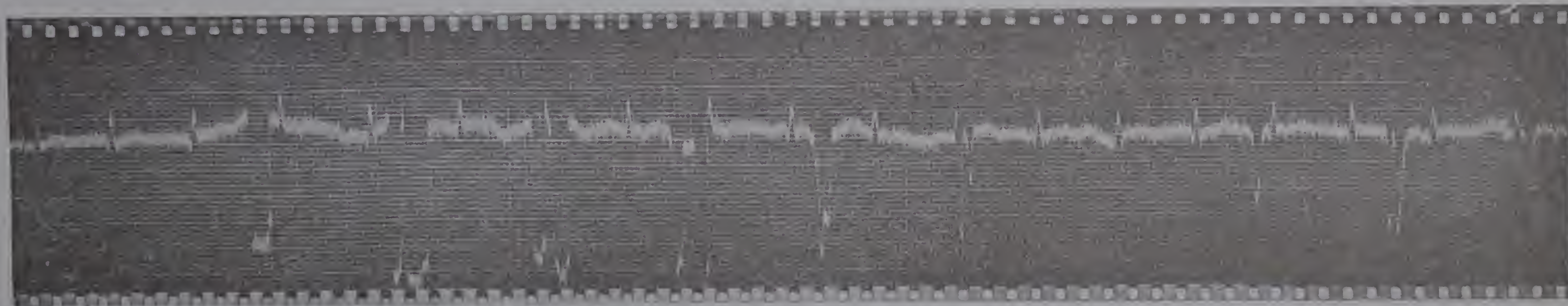

Fig. 123: Same experiment as fig. 122, but a male (Mr v. d. S.) lay on the table in the direction of the line X, facing upwards. Dowser moved parallel to the axis of the trial person, with arms perpendicularly to the axis and above it. First the feet were passed (left side of diagram) then the head, right hand passing first. Several peaks appeared in the diagram indicating induction potentials caused directly or indirectly by the body on the table. Experiment took place immediately after experiment of fig. 122.

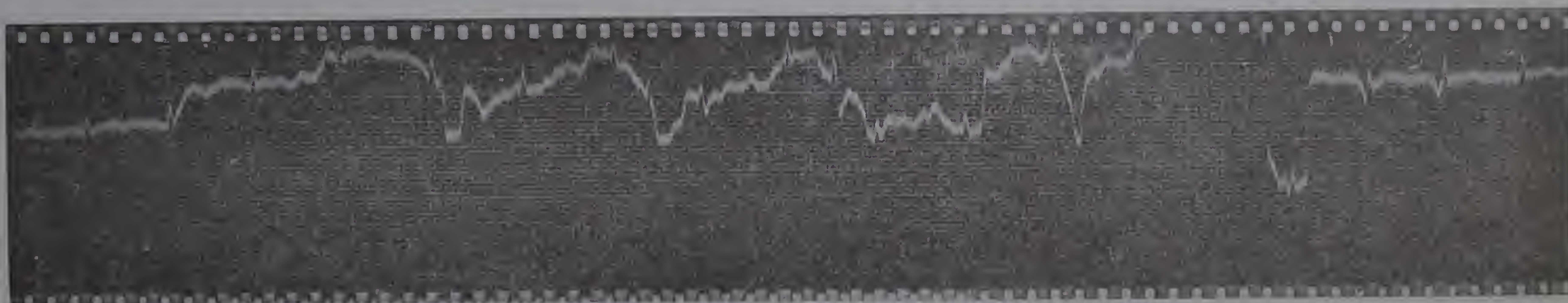

Fig. 124: Same experiment as fig. 123, taking place immediately afterwards. Dowser moved this time perpendicularly to the axis of the trial person along the head of the person. Irregular peaks appeared in central part, indicating potential changes up to 20 mV and more. Abt. 40 cm from the head the cardiogram was regular again (left and right end of diagram).

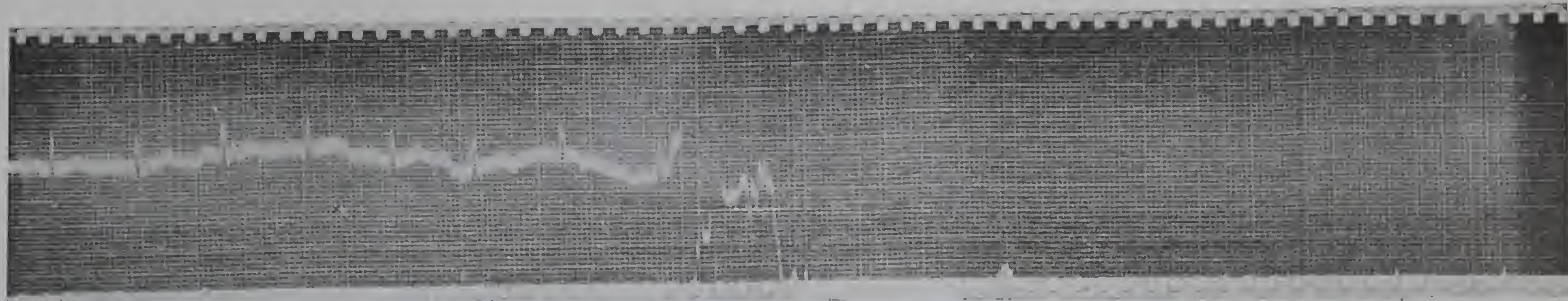

Fig. 125: Same experiment as fig. 124, taking place immediately afterwards. This time dowser did not move but rolling table with the body was moved, head passing the dowser holding a divining rod. Table started movement abt. 75 cm from the dowser, which explains the regular curve at left end of cardiogram. After the head reached the dowser considerable excursions of the string took place of the order of 25 mV and more.

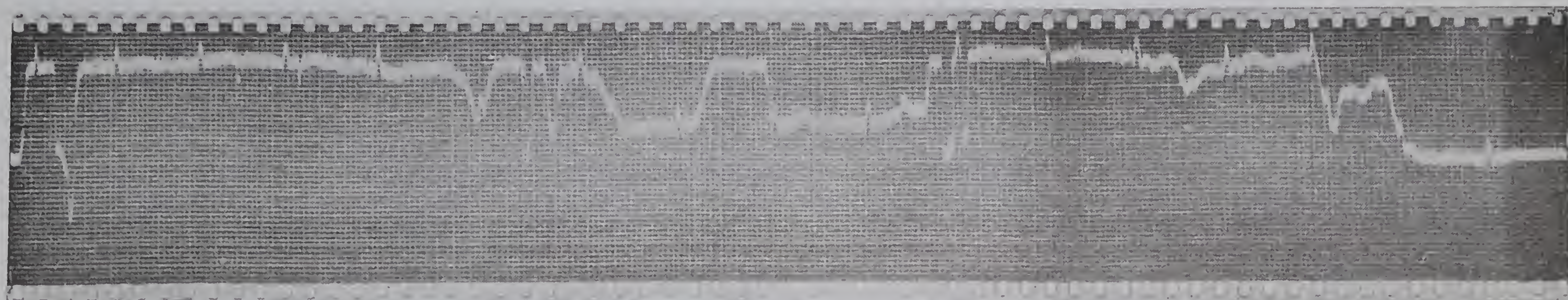

Fig. 126: Same experiment as fig. 123 on September 23rd, 1946.

Fig. 127: Same experiment as fig. 124 on September 23rd, 1946.

Fig. 128: Same experiment as fig. 124, but this time the trial person was a female (Mrs DE G., same person as in fig. 115).

Fig. 129: Same experiment as fig. 103, but in small room annex (see fig. 99). All Q-peaks exactly on a horizontal straight line in cardiogram. Date of experiment: October 7th, 1946.

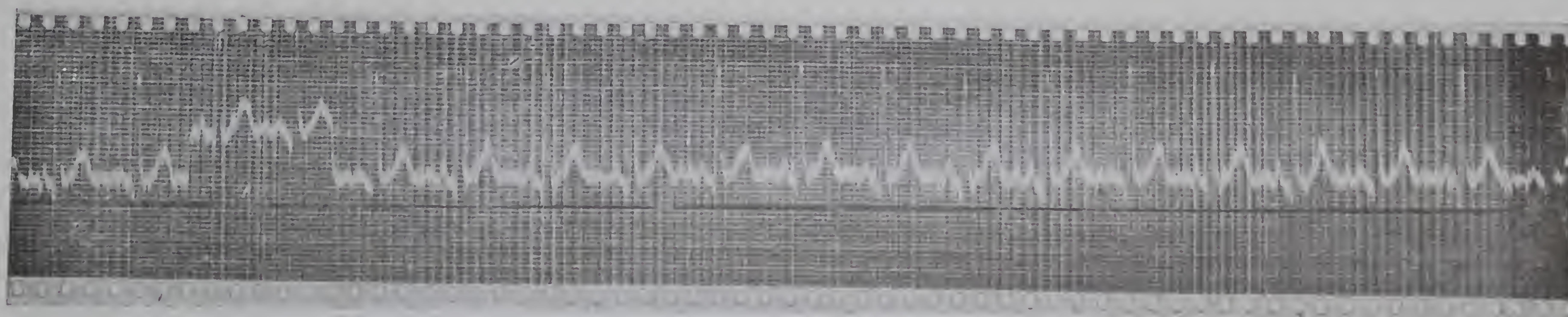

Fig. 130: Immediately after experiment 129 the divining rod was held for 12 seconds above the feet of a female lying on a table (Mrs DE G.), dowser (Mr T.) standing quietly. The horizontal level of the Q-peaks suddenly moved upwards abt. 0.5 mV (compare figs 129 and 130). During the experiment the position of the string was not changed artificially with the regulating battery of the string-galvanometer.

Fig. 131: Same experiment as fig. 130 (immediately afterward), but this time the rod was held above the middle part of the body. Horizontal level of Q-peaks was the same as in fig. 129, but 0.5 mV lower than in fig. 130.

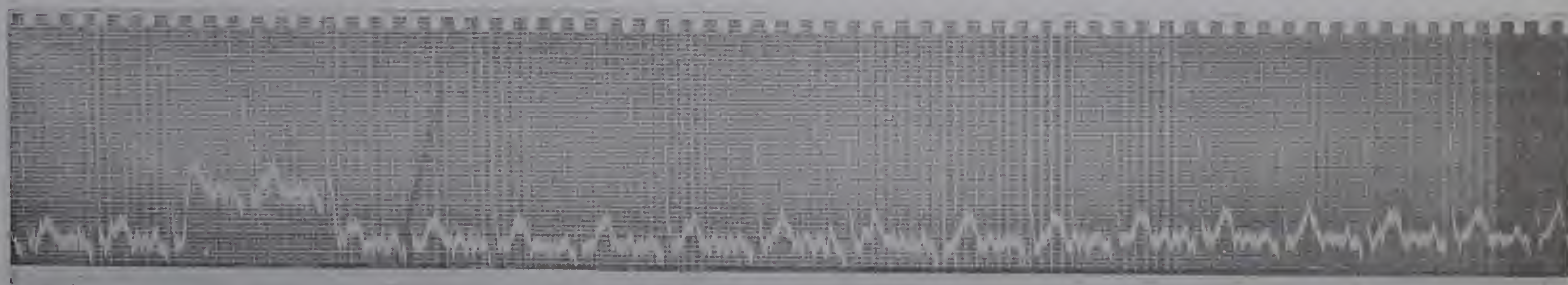

Fig. 132: Same experiment as fig. 130 (immediately after experiment of fig. 131), but rod was held above the head of the trial person. Horizontal level of Q-peaks suddenly subsided abt. 0.8 mV with respect to fig. 129, curve as a whole gradually rises at right end of cardiogram.

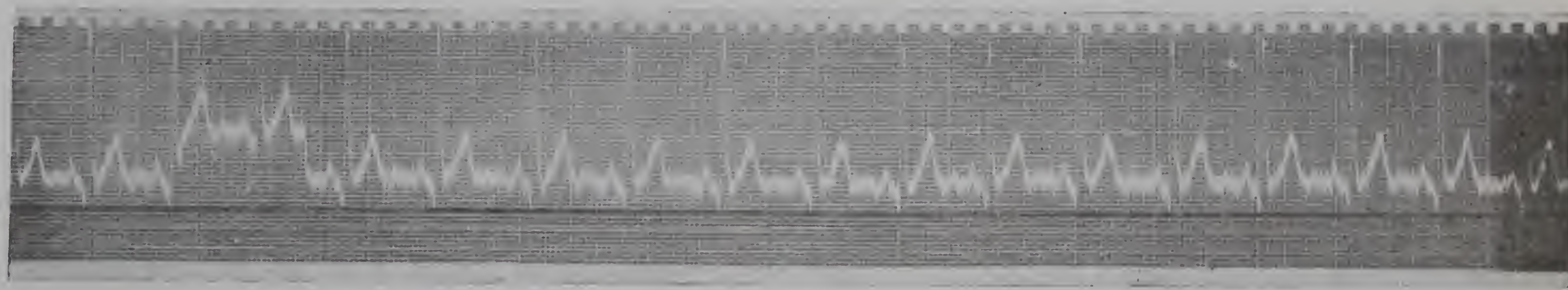

Fig. 133: Same experiment as fig. 129, repeated on October 14th, 1946.

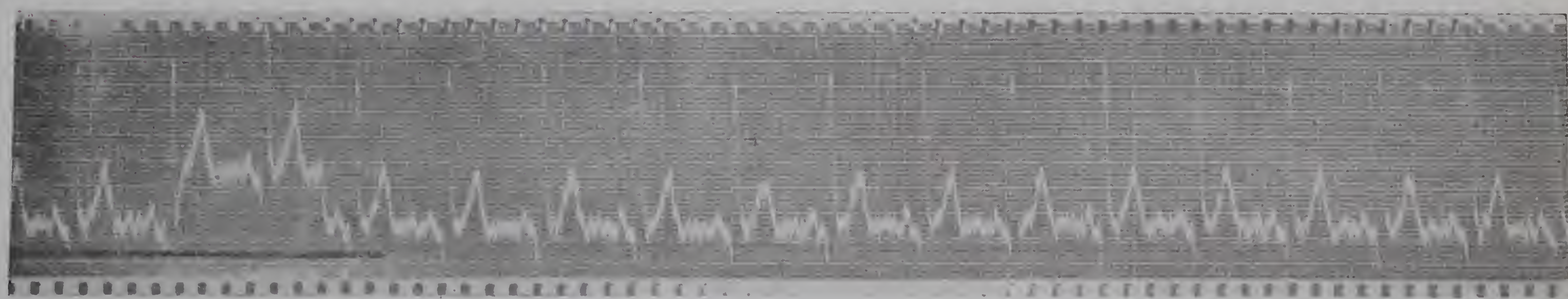

Fig. 134: Same experiment as fig. 132, but rod was held above the head of another female trial person (Mrs DE S.), for 24 seconds. After first 3 seconds horizontal level of Q-peaks suddenly subsided abt. 0.8 mV with respect to fig. 133. Subsidence continued for the following 21 seconds (see fig. 135) and amounted to 1.2 mV after 24 seconds.

Fig. 135: Continuation of fig. 134.

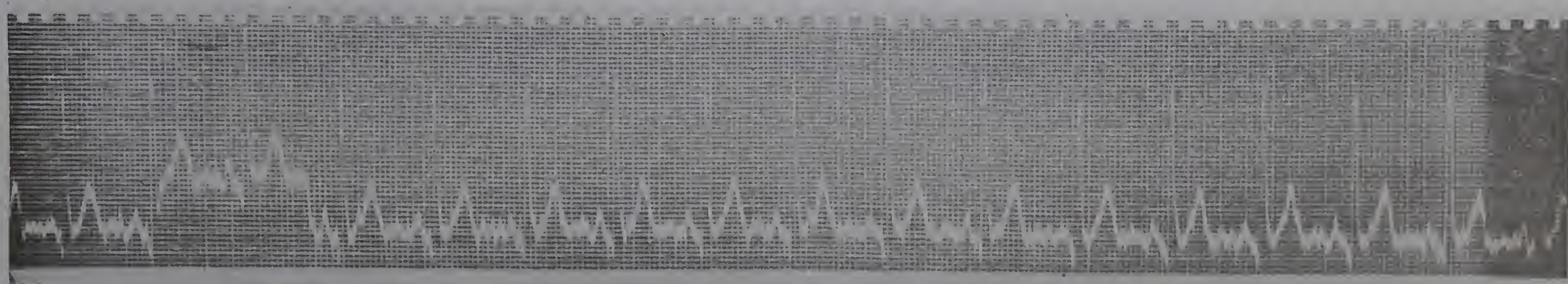

Fig. 136: Immediately after experiment of figs 134 and 135 dowser (Mr T) moved 1 M. backwards; string was not regulated and level of Q-peaks remained at low but constant level.

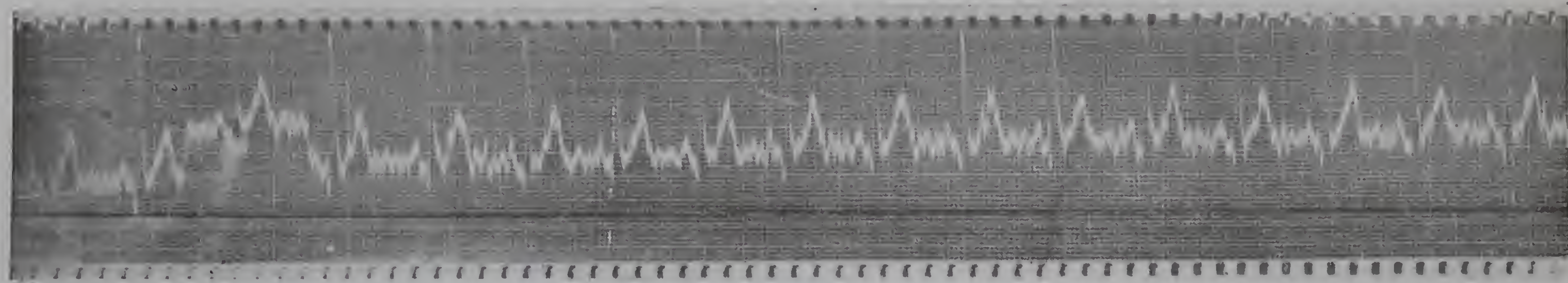

Fig. 137: Dowser (Mr T.) moved forwards again after experiment of fig. 136 and held divining rod quietly for 24 seconds above the head of a male trial person lying on a table (Mr T. Sr). General level of Q-peaks suddenly moved upwards abt. 1 mV (compared with fig. 136) and curve as a whole gradually rose.

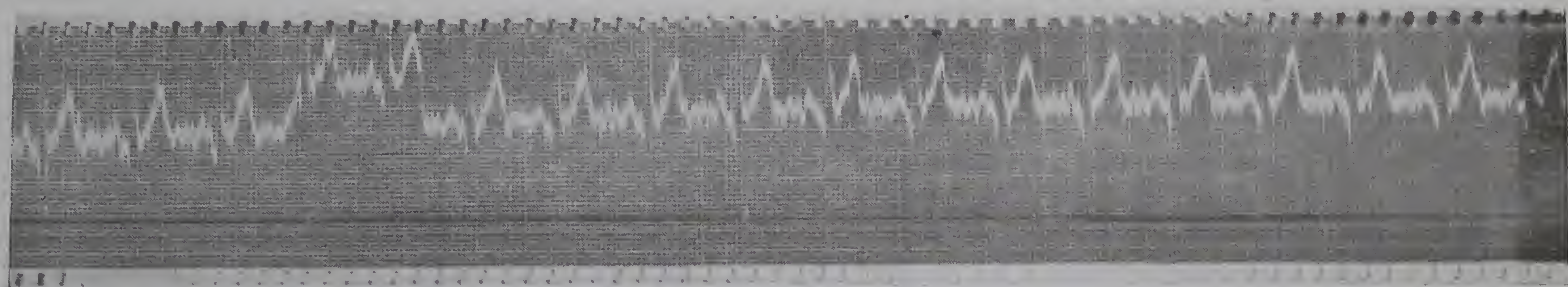

Fig. 138: Continuation of fig. 137. The curve still rose and after 24 seconds a potential change of 3.2 mV was created compared with fig. 136.

Fig. 139: Same experiment as fig. 129, repeated on October 21st, 1946; standing quietly outside a zone of disturbance near the ring of a tangent galvanometer (see fig. 96). Ring without current.

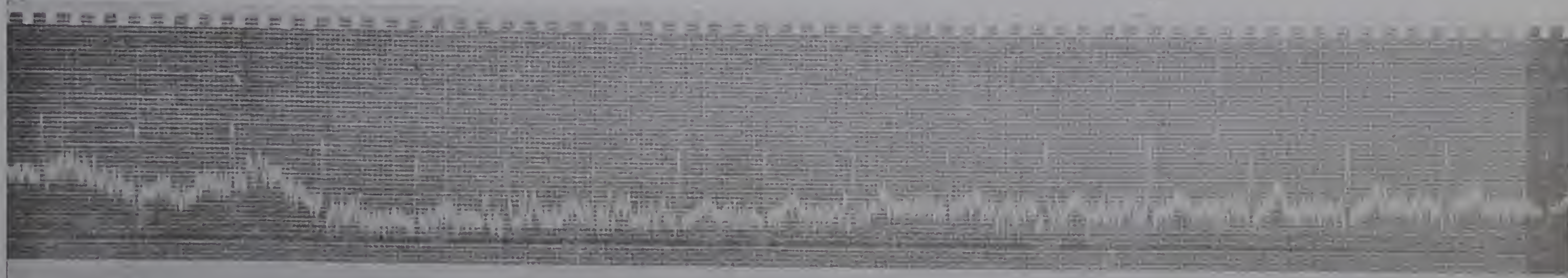

Fig 140: After experiment of fig. 139 dowser moved slowly perpendicularly to the axis of the ring of the tangent galvanometer; galvanometer ring of 1 M. diameter, with one wire and a current of 10 A, created a magnetic field near the ring of abt. 0.125 Gauss. After first 2.5 seconds general level of Q-peaks subsided suddenly abt. 3.8 mV. Whole curve gradually rose abt. 1 mV after 12 seconds

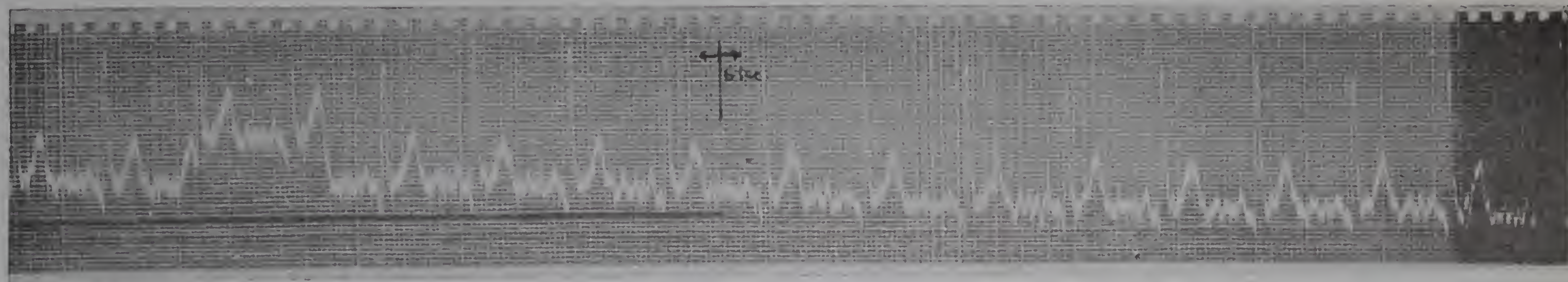

Fig. 141: Dowser was standing quietly in front of the tangent-galvanometer, ring of galvanometer placed horizontally. Rod and electrodes similar to experiment of fig. 103. A current of 10 A was switched on in the ring, but the bundle of the magnetic lines of forces was mainly vertical and nearly did not reach the dowser. Q-peaks remained at a constant horizontal level (left side of fig. 141). After 6 seconds the ring of the galvanometer was moved upwards and remained in this position for the following 18 seconds (see also fig. 142). The level of the Q-peaks subsided and reached a minimum of abt. 1 mV after abt. 10 seconds (see fig. 142).

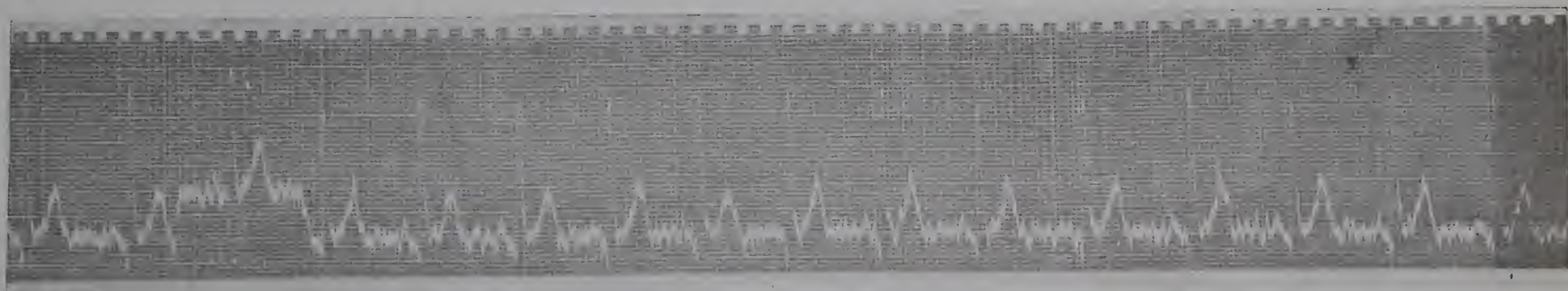

Fig. 142: Continuation of fig. 141.

Fig. 143: Dowser (Mr T.) sitting quietly in a closed moving automobile with rod and electrodes similar to fig. 100. During this experiment (on March 29th, 1947) the car was driven along an asphalt road in Wassenaar (near The Hague, Holland). A later test with an ordinary divining rod (without string-galvanometer) indicated that no dowsing zone occurred along this road. A 36-seconds diagram (see also fig. 144) indicated that even in a moving car all Q-peaks remained exactly on the same level if no external disturbing zones occurred.

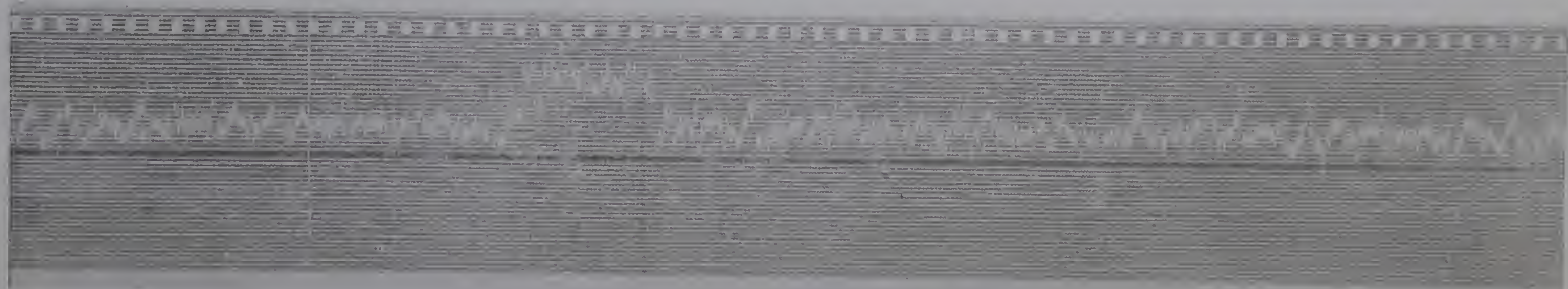

Fig. 144: Continuation of fig. 143.

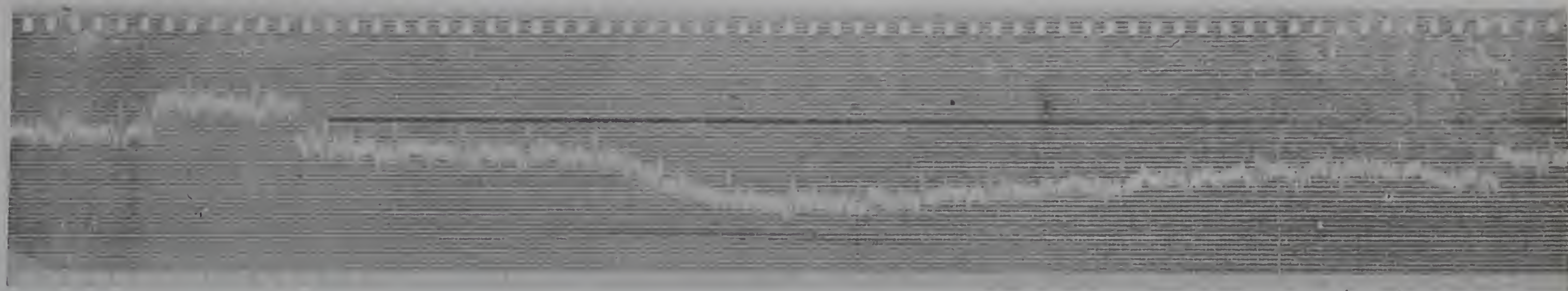

Fig. 145: Driving in the same car as in fig. 143, the car passed a canal in Wassenaar; this normally caused a turning of the rod. The rod did not turn during the experiment, as it was placed in loose insulated grips. Electrodes were connected similar to fig. 100. As soon as the car with the dowser entered the neighbourhood of the canal the curve subsided. At the end of the canal the curve returned to the original level (see also fig. 146).

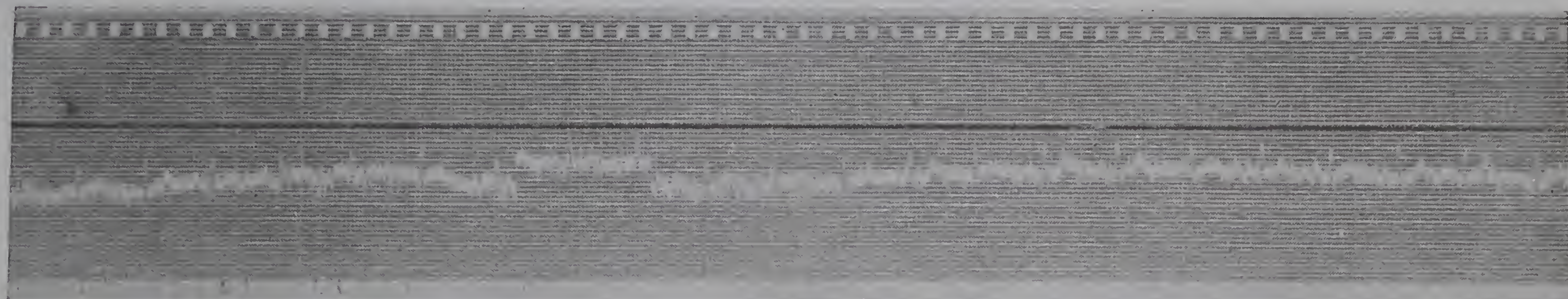

Fig. 146: Continuation of fig. 145.

Fig. 147: Electro-cardiogram of same dowser as in experiment of fig. 143, driving in a car across a large iron bridge over the "Galgewater" at the "Haagsche Schouw" (near Leiden Holland). The diagram was registered for 60 seconds and started at a point abt. 100 m before the bridge. Figs 147, 148 and 149 (left side) indicate a gradual rise of the curve of abt. 10 mV. At the right side of fig. 149 the car entered the bridge and passed above the river. The curve suddenly subsided abt. 18 mV (i.e., 8 mV below the initial level of fig. 147) and recovered slowly after the bridge was crossed (see fig. 150). It was normal again 50-100 m after the bridge.

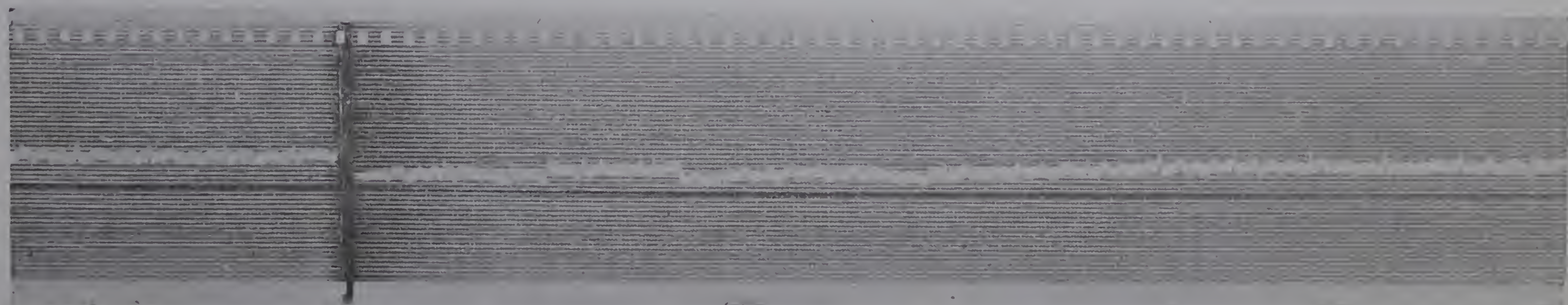

Fig. 148: Continuation of fig. 147.

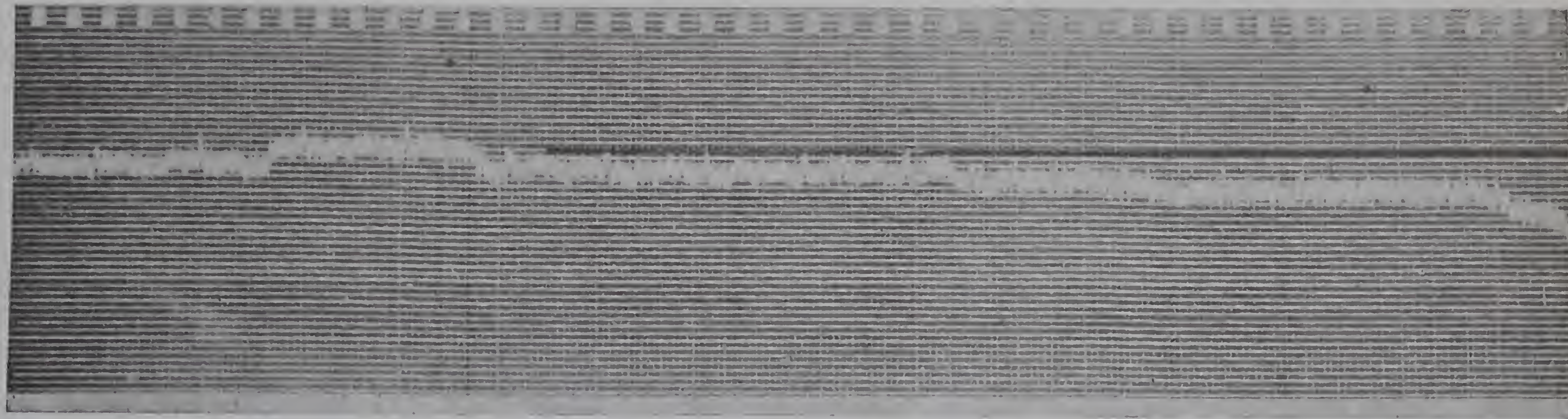

Fig. 149: Continuation of fig. 148.

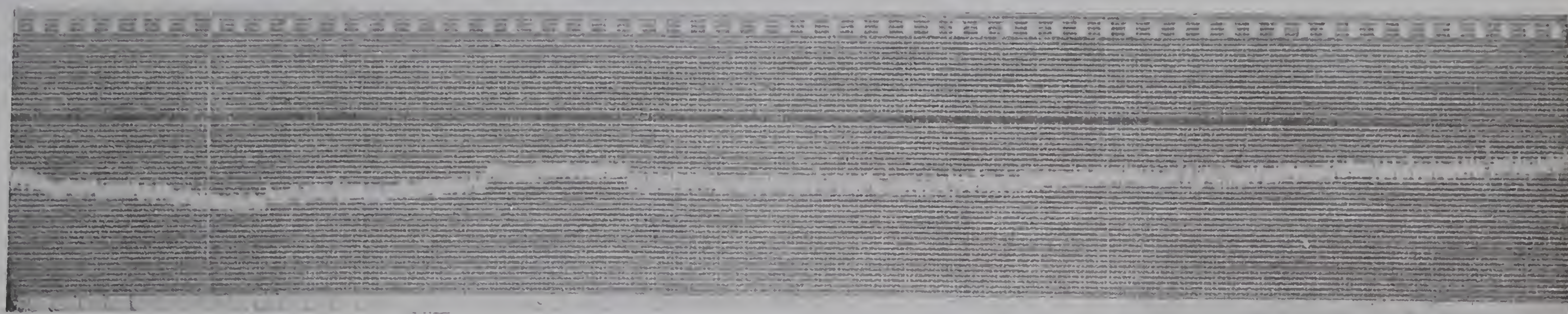

Fig. 150: Continuation of fig. 149.

APPENDIX I: SUMMARY OF BASIC PHYSICAL CONCEPTIONS AND UNITS USED IN THIS PUBLICATION

I. ELECTRICITY

A. Definitions

Field-strength (F) is the force exerted on the unit of electricity in an electric field.
Potential (V) at a point A is the energy required by the field-strength to move the positive unit of electrostatic charge from point A to the infinite.
Potential difference: difference in electric tension between two points in an electric circuit.
Electrostatic capacity or *capacitance* (C) is the property of a circuit or apparatus by virtue of which it can hold a charge of electricity.
Lines of force are imaginary lines representing the orbits of a unit of electric charge in an electric field; they are perpendicular to the equipotential surfaces, the outer surface of a conductor being one of them.
Equipotential surfaces are surfaces connecting points of the same electric potential.
Gradient of the field-strength is the change in field-strength per cm distance, usually calculated by dividing the difference between the field-strength at two points by the distance in cm of those points.
Electro-motive force (E = e.m.f) is the source of energy that causes electricity to flow.
Current (*I*) is the rate of flow of electricity.
Resistance (R) is that property of material that opposes the flow of electricity through it. It varies directly with the length and inversely with the cross-sectional area.
Self-induction is the property of a circuit that opposes any change in the value of the current flowing through it and is due to the magnetic field which surrounds a conductor carrying a current.
Inductance or *coefficient of self-induction* (L) of a circuit is the constant by which the time rate of change of the current in the circuit must be multiplied to give the e.m.f. induced in the circuit by such change.
Impedance (Z) of a circuit is the resistance offered to the passage of alternating current, depending on the frequency of the current, the resistance, inductance and capacity of the circuit. $Z = \sqrt{R^2 + X^2}$.
Reactance (X) is that part of the resistance offered to the passage of alternating current which is due to the inductance and capacity of the circuit. $X = 2\pi n L - \frac{I}{2\pi n C}$ (if n = frequency of alternating current).
Phase of alternating current is the time relation between the current and potential in an alternating current circuit. If the current reverses after the potential, it is said to be out of phase. *Conductivity* of a circuit is the reciprocal value of resistance of that circuit.

B. Laws

1. *Law of Coulomb*: $K = \frac{q_1 \times q_2}{r^2}$ dyne if K = force of attraction or repulsion between two electric charges q_1 and q_2 at a distance of r cm.
2. *Laws of electrostatic potentials and charges*:
   a. Electric charge of a closed conductor is concentrated on the surface.
   b. The density of electric charge is greatest at those places of the conductor which possess the strongest curvature.
   c. The induced charges (positive and negative) are always the same in magnitude, but each of them is smaller than the inducing charge.
   d. Positive electric charges always flow from the conductors with highest potential to those with lower values.
   e. The electric potential in and on a conductor is everywhere the same.
   f. Electric potential on a globe $= \frac{Q}{R}$ (Q = charge, R = radius).

3. *Laws of capacitance*:
   a. Capacity of a spherical conductor in E.S. units = radius of the sphere in cm (R).
   b. Capacity of non-spherical objects far from other conductors and the earth depends on the shape and dimensions of the body.
   c. Neighbourhood of a conductor, increases the capacity (C) and decreases the electric potential (the electric charge $Q = C \cdot V$).
   d. The capactiy of a condenser composed of two globes with radii R_1 and R_2, $C = \frac{R_1 \times R_2}{R_1 - R_2}(R_1 > R_2)$; in case of plate condensers with surface $= S$, distance of plates $= d$, the capacity $C = \frac{KS}{4\pi d}$ if $K =$ dielectric constant of the insulator between the plates (K for glass = 6, for ebonite 2—3).
   e. When two or more condensers are connected *in series*, the reciprocal of the total capacitance is equal to the sum of the reciprocals of the capacitances. If they are connected *in parallel* the total capacitance is equal to the sum of the capacitances.
4. *Ohm's laws*: $I = \frac{E}{R}$ (direct current); $I = \frac{E}{Z}$ (alternating current in conductor); $I = \frac{E}{R_1 + R_e}$ (R_i = internal resistance of electrolyte, R_e = external resistance of wire).
5. *Laws of series and parallel circuits carrying direct current*:
   a. In a *series circuit*, (i.e., the total current passes through each part of the circuit, in other words each positive pole is connected to the negative pole of the following part of the circuit) the total resistance is equal to the sum of the resistances of its component parts ($I = \frac{nE}{nR_i + R_e}$ n = number of elements)
   b. In a *parallel circui* (i.e., all positive poles on one side and all the negative poles on the other are connected and the ends of both separate connecting wires are united) the current in each circuit is inversely proportional to the resistance of each branch of the circuit and the reciprocal of the total resistance of the circuit is equal to the sum of the reciprocals of the branch resistance ($I = \frac{E}{R_{i/n} + R_e}$).
6. *Laws of Kirchhoff*:
   a. The algebraic sum of the currents that meet at any point in a conducting circuit is zero.
   b. In any closed circuit, the algebraic sum of the products of the current and resistance of each part of the circuit is equal to the e.m.f. in the circuit.
7. *Law of Joule of thermo-electric heating*: when an electric current passes through a solid conductor the electric energy expended is entirely convered into heat energy. $H = 0.24\ I^2RT$ gcal (T = time in seconds, R = resistance in ohm, I = current in ampère).
8. *Laws of Faraday for electrolytes*:
   a. The amount of decomposition in an electrolyte is proportional to the current and to the time for which it passes.
   b. The amounts of different substances liberated by the same current, flowing for the same time, are proportional to the chemical equivalents of the substances.

C. Units

Unit of electricity = 1 *coulomb* = 10^{-1} E.M. units = $3 \cdot 10^9$ E.S.U.
Unit of potential:
Electrostatic unit is the potential that requires 1 erg energy (see above def. potential).
Practical units: 1 volt = $^1/_{300}$ E.S.U.; 1 millivolt = 10^{-3} V;
1 μV = 10^{-6} V; 1 kV = 10^3 V.
Unit of potential difference: 1 V.
Unit of capacitance: practical unit is 1 *farad* = capactity of a circuit that requires the unit of electric charge (1 coulomb) to be charged to a potential of 1 volt; 1 microfarad = 10^{-6} F = $9 \cdot 10^5$ E.S.U.
Unit of electric current: 1 A = 10^{-1} E.M.U. = $3 \cdot 10^9$ E.S.U.
It is a current characterized by a flow of electricity of 1 coulomb per sec. through each cross-section. It is also defined as the current flowing through a circuit of 1 ohm resistance when an electro-motive force of 1 V is impressed on it.
Unit of resistance: 1 *ohm* = resistance of a circuit in which a current of 1 ampère flows when subjected to an e.m.f. of 1 V.
Unit of electric energy: 1 *Joule* = 1 *Watt/sec* = work done when 1 ampère flows through a resistance of one ohm for one second.
Unit of electric power: 1 *Watt* = rate of expended electric energy per unit of time.
Unit of inductance: 1 *Henry* = inductance of a circuit where a change of 1 ampère per sec will induce 1 V e.m.f.
Electrical constants of divining instruments:
Capacity of steel divining rod (see fig. 86) = 6 microfarad;
Resistance of same rod = 0.1 ohm;
Resitance of shoes > 10^6 ohm;
Surface resistance of a freshly cut wooden twig > 10^6 ohm;
Leakage of ebonite handles used in experiment = 200 V in 8 minutes

II MAGNETISM

Definitions and units have been discussed on p. 74 and 209.

III ELECTRO-MAGNETISM

A. Laws indicating relation between electric currents and magnetic field

1. *Law of Biot-Savart* $K = \dfrac{m\, i\, l \sin(l,r)}{r^2}$ if K = force exerted by an electric current (i) passing through a circuit element (of 1 cm) on a magnetic north pole (with polar strength m) at a distance r; (l.r) represents the angle between the line connecting the circuit element l and magnetic pole, and the direction of l.
2. *Right-hand rule of Ampère*: if the right hand is placed parallel to the current, palm towards the magnet and index finger in the direction of the current, the north pole of the magnet deviates in the direction of the sidewards stretched thumb.
3. *Left-hand rule of Fleming*: if the index finger of the left hand indicates the direction of the current and the lines of force penetrate the hand at the palm, the sidewards stretched thumb indicates the direction of the force exerted by the magnetic field on the conducting wire of the current.
4. *Cork-screw rule of Maxwell*: the direction of the field-strength along the magnetic lines of force created by a circular conducting wire, with an electric current in it, is such that the bundle of lines of force (being more or less perpendicular to the ring) can be represented by a corkscrew turning clockwise into the surface of the conducting ring, the current in the ring moving clockwise too.
5. *General rule of Maxwell*: a closed conductor in a magnetic field is subjected to forces that try to turn the conductor in such a way that the conductor catches as many lines of force as possible.

6. *Induction laws of Lenz*:
   a. If the number of the lines of force enclosed by a conductor increases (or decreases) an induction current is created in the conductor which does not correspond (or corresponds) with the magnetic field (see cork-screw rule).
   b. The direction of the induction current is such that it always counteracts the current that created the induction current.
   c. The quicker the change in number of enclosed lines of force, the shorter the induction current will last, but the larger its magnitude will be.

B. Polarization phenomena and properties of crystalline substances

Polarized light: electro-magnetic radiation vibrating in only one plane, contrary to normal light with vibrations taking place in all directions perpendicular to the direction of transmission. It is obtained artificially if light passes certain crystals e.g., calcite rhombohedrons (two parts glued together, forming a *nicol*).
Velocity surfaces are imaginary surfaces obtained by connecting the points reached in the unity of time by a light wave radiating from a central point. Three fundamentally different surfaces are distinguished: globular surfaces (in isometric crystals); biaxial, rotational ellipsoids (in hexagonal, trigonal and tetragonal crystals) divided in optical positive and negative crystals, depending on the shape of the biaxial rotational ellipsoid; triaxial ellipsoidal surfaces (in orthorhombic, monoclinic and triclinic crystals).
Definition of crystals: crystals are homogeneous discontinuous media, generally with anisotropic physical properties. They are solid or fluid and are mostly bound by plane surfaces.
Crystal space lattices: matter gives the impression of being a continuum, i.e., the space should be filled up completely with small particles of matter. Crystals possess *space lattice structures*, composed of geometrically arranged ions or molecules, occurring at the nodal points of the imaginary space lattices. In other words the space is not completely filled up — it is a discontinuum. The distances between the nodal points are 10^{-7} - 10^{-8} cm. MAX VON LAUE discovered that X-rays give diffraction diagrams in these space lattices, similar to diffraction phenomena with ordinary light passing through macroscopic lattices. VON FEDOROW and SCHOENFLIESZ discovered that only 230 different point systems occur in crystalline substances which explain all physical properties of crystals.

IV GENERAL PHYSICAL UNITS

1 E.M.U. = 1 electro-magnetic unit = $3 \cdot 10^{10}$ electro-static units (E.S.U.).
1 Mikron = 1 μ = 0.001 mm
1 millimikron = 1 $m\mu$ = 10^{-7} cm
1 Angstrom unit = 1 Å.U. = 0.1 $m\mu$ = 10^{-8} cm
Unit of light intensity = 1 Hefnercandle = light produced by a lamp of isoamylacetate with a wick of 8 mm thickness and a flame of 40 mm length.
1 International candle = 1.11 Hefner candle
1 Lux = illumination produced by one Hefner candle at 1 m distance with radiation perpendicular to the illuminated surface.
1 Dyne = force which gives an acceleration of 1 cm/sec^2 to a body with a mass of 1 gram.
1 erg = energy expended by a force of 1 dyne if the point of application moves 1 cm in the direction of the force.
1 kgm = energy expended by a force of 1 kg if the point of application moves 1 m in the direction of the force = $9.8 \cdot 10^7$ erg. Mechanical heat equivalent: 1 kgcal = 427 kgm energy
1 gcal = $4.2 \cdot 10^7$ erg = 4.2 Joule.

APPENDIX II: ADDITIONAL NOTES CONCERNING THE SENSITIVITY FOR DIRECTION OF ANIMALS

On p. 389 we discussed briefly the main physical theories which have been advanced to explain the extraordinary capacities of homing pigeons. In 1942 Dr H. L. YEAGLEY, Associate Professor of Physics, Pennsylvania State College, U.S.A., formulated a new theory that combined the magnetic and coriolis effect. In order to prove his theory he started a series of experiments in May, 1943, the first actual tests were made in November, 1943. He used homing-pigeons trained to fly to Paoli, Pennsylvania. The results of his experiments, which were witnessed by officers of the U.S. Army Signal Corps, have been compiled in secret Army Signal Corps reports and in his publication: ,,*A preliminary study of a physical basis of bird navigation*'' (see bibliography attached to this appendix).

The first clue to YEAGLEY's theory was given by the observation that homing pigeons near Indianapolis (Indiana) failed to return to the lofts situated in an area of the U.S.A., where the lines of equal magnetic-vertical intensity and the latitude lines (indicating the coriolis forces) are parallel.

In order to locate ourselves on earth we need two intersecting lines: two light beams, two radar beams, etc. YEAGLEY assumed therefore that birds are sensitive to two kinds of overlapping physical fields, a grid pattern formed by the lines of equal magnetic vertical intensity and lines of coriolis, which are parallel to the latitude lines. These two grids usually intersect, because of the displacement of the earth's magnetic poles from the rotational poles. YEAGLEY based his experiments on a number of observations concerning the habits of carrier pigeons (also called homing-pigeons), which he summarized as follows:

1. ,,When released at unfamiliar and distant points, they usually fly in large circles for a matter of minutes before moving off in a straight line. When training flights have been experienced once or twice daily for weeks, and pigeons are released individually from new locations around the compass, they often sense the correct direction, after having flown only one or a fraction of a complete circle.

2. Homing pigeons are unable to navigate in a thick haze or fog or in complete darkness. Blinded or hooded birds fly first in a large circle and then in a decreasing spiral, gradually descending until about six feet above the ground level, after which a ,,crash''landing is made.

3. Pigeons are unable to navigate succesfully in winds much over thirty-five miles per hour, the actual limit for accurate navigating being 12 miles per hour.

4. After reaching four or five weeks of age, homing pigeons can be trained ,,around the compass' for six or eight weeks at increasing distances at one, two, four, eight, sixteen, thirty-two miles (repeating each distance one or two times before increasing), after which they are easily capable of navigating flihgts of distances up to seventy miles and more. With a few more weeks of training, flights of one or two hundred miles, or even more, are readily accomplished. A year later, with some additional short training flights added to their experience, they can readily navigate home from four hundred miles, *without previous experience of any kind in the new territory*.

5. Written reports by the Army and Navy Communications as well as numerous oral reports by representatives of flying clubs and individuals indicate that pigeons are confused and are unable to orient themselves when released from points near powerful radio and radar broadcasting stations. There are some indications that the *audio-frequences rather than the carrier frequencies are the disturbing factor*.

6. Successful navigating results are mainly obtained in the morning before 12 *a.m.*

7. Pigeons require always a considerable training before their homing capacities are fully developed.''

Several of YEAGLEY's experiments seem to support his theory:

1) The failures at Indianapolis (1942) as mentioned above; the experiment was repeated in June 1945.

2) The *magnetic wing experiment* (November 7, 1943): Hyflux-chrome magnets were attached on the underside of the wings of a number of pigeons between the first and second joints; another group of pigeons were given copper (non-magnetic) plates of approximately the same mass and size (1 . ″0.218″ · 0.025″, weighing abt. 0.8 gram). Assuming that the magnets move up and down with a harmonic motion and estimating the wing beats at 180/sec, amplitude $^1/_8$ foot, YEAGLEY calculated that 0.12 microvolt/cm must be indiced in the birds body. This value is of the same order as the change of e.m.f., which (according to calculations of YEAGLEY) occurs in birds flying eighty miles toward or away from the normal magnetic vertical line at 45° latitude. YEAGLEY assumed that the continuous change in e.m.f. from zero to 0.12 microvolt/cm and back to zero again, etc., is bound to confuse and upset the bird's direction-finding organs (see theobase of nerves, p. 136).

20 outstanding, well-trained homing pigeons were used in the experiment; they were released 65 miles from the loft. It was found that no soreness or injury resulted from the attachment of the metals. The experiment showed the following results:

a) 5 of 10 birds with copper plates returned within 1 day, 3 within 2 days; total 8;

b) 1 of the 10 birds with 2 magnets returned after 4 days, 2 of them lost both magnets and returned also after 4 days; of those birds who lost one magnet, only 1 returned within 1 day, 2 after 4 days. The other 4 never returned. In other words, only one bird managed to return within 4 days and this bird lost one of the magnets. The fact that 1 bird with 2 magnets returned at all may seem to contradict the expected result. However, these homing pigeons, trained in home hunting, may have found their loft after 4 days by discovering certain known landmarks.

YEAGLEY also recorded the direction in which the birds left the release point.

a) Of those with copper plates: 3 deviated less than 10° from a direct line toward the home loft, 3 less than 30°, 4 less than 50°.

b) Of those with magnets: 4 deviated 45°, 2 more than 90°, 3 about 130°, 1 about 180°.

This experiment, although not conclusive considering the small number of birds, supports the magnetic theory. We must bear in mind, however, that if the bird's navigation is due to another phenomenon (e.g., some kind of biological radar) it probably requires anyhow the bird's nervous system. The influence of magnets may be disturbing only to the nerves (similar to the effect of radio transmitters) and not due to a neutralizing effect on the magnetic sensitivity of birds.

3) *The Nebraska experiment* (June—July 1944): 10 miles N. of Kearney in Nebraska a place occurs with values of magnetic vertical intensity identical to those of State College, Pennsylvania. The pigeons were trained at State College, after which the birds and lofts were transferred to Kearney. The experiment were carried out to demonstrate whether the birds would return to State College as usual, or to this conjugate point near Kearney. The result was quite satisfactory. A number of birds returned to their lofts near Kearney, others terminated within 10 miles of this place; very few of the 122 birds were found East of Nebraska. The conditions were rather difficult for the birds because there is not one, but two points near Kearney 25 miles apart with magnetic conditions similar to State College.

Other experiments are described in the above-mentioned publications.

In order to collect more evidence for the magnetic theory it seems advisable first to find an answer to the following questions:

1) Do homing pigeons react on magnetic fields, e.g., slowly pulsating fields etc., and if so, what is their behaviour if they are released after being exposed previously to an artificial magnetic field (e.g., created by the ring of a tangent galvanometer)?

2) What is the rheobase of pigeon's nerves?

3) If homing pigeons are trained for a long period and can always return to their loft, are they able to do so if released from an area with strong magnetic anomalies (basic igneous rock area, for example)?

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In the section on rhabdomancy and radiesthesia all the publications known to the author have been included. Still we are convinced that many were omitted. With an asterisk those publications were indicated which are the most important ones and with a capital "A" in brackets (A) those authors were indicated who did not believe in the reality of divining phenomena.

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